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Details and Objectives That May Be Overlooked When

Planning an Installation of Electrical Equipment

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PLANNING the layout of an electrical system for an industrial plant requires vision and foresight, as well as sound engineering knowledge. When a definite problem is presented, in which all factors are known, finding the solution is in many cases largely a matter of applying well-known formulas. However, good judgment alone, based on experience, must be relied upon to solve some of the problems on whose correct solution a good deal depends in the way of economy of installation and operating efficiency. In this article Mr. Phillips discusses some of the objectives and details that are likely to be overlooked when plans for an electrical installation are being made.

IN A modern industrial plant the total cost of the electrical equipment represents a fairly large percentage of the total cost of the project, and yet it is, unfortunately, sometimes treated as a minor item in the planning of the installation as a whole. Furthermore, although many of the engineering problems are given the consideration they merit, it is not uncommon to find that many important details have been overlooked, with the result that a great deal of unnecessary trouble and expense are caused later on. Trouble-free installations of electrical equipment are not the result of chance; nor can continuity of operation and low operating costs be expected when the installation has been planned and the equipment installed in a haphazard manner.

I am a firm believer in a good, clean-cut electrical installation, and in this article I will discuss briefly some of the points that I have found by experience are likely to be overlooked.

In planning any installation, the following objectives and considerations should be kept firmly in mind:

(1) To make the installation as safe and as accessible as possible for the operators and maintenance men.

(2) Expense should be kept down as much as possible, *without endangering a good, safe layout.*

(3) The most economical centers of distribution should be selected, considering the location of the equipment and the driven machinery.

(4) Number of main feeders that should be run.

(5) Over-capacity to be allotted to the main feeders, which will be based partly on the number of motors that will be tapped off in the future.

(6) How much of the wiring should be run in conduit?

(7) Purchase equipment that has been proven by practical experience to be the most reliable and require the least amount of maintenance to keep it in first-class condition.

(8) Endeavor to see that the equipment is so located that it will not be in the way of other machinery and yet be accessible for operation and repairs.

Taking these points up in order, (1) to make the installation as safe electrically as possible for the operators and repairmen, there must be a minimum of exposed, live parts. Furthermore, to make it safe for the maintenance men, while changing fuses and making repairs, it must be as accessible as possible, so that it will not be necessary for them to climb ladders, or work in close, dangerous places. Fifty per cent of the burns and other accidents to electrical workers can be traced to the poor conditions under which they are working. With industrial plants striving as hard as they are to cut down the number of accidents that occur each year, proper installation of the electrical equipment, which makes for safer working conditions, is an important factor in making this huge drive a success.

(2) *Keeping Expense Down*—If first cost only is being considered when planning and laying out an electrical installation, the one that is least expensive at first is more than likely to be the most expensive in the long run, due to equipment failures with their resultant produc-

tion delays and high maintenance cost.

Failures in Junction Boxes

For example, when expense is the only point considered in laying out a new electrical installation, the main power feeders are most frequently run through the building high up on the wall or ceiling, junction boxes being located where it is decided to tap off for motor circuits. Another cutout box with fuses is mounted alongside it, with a line run from there to the motor starting equipment. This arrangement is open to a number of objections. First, it is very difficult to make a good splice in a junction box and solder it without damaging the insulation, unless the box is made unnecessarily large. I have seen a great many grounds and burnouts occur in junction boxes that were part of a new installation that had been in service only a short time, as well as in old installations.

These failures in junction boxes usually damage the wiring back into the conduit, so that the splice will have to be taken apart and a length of conduit removed on both sides in order to make a temporary splice in the wiring. In the meantime production is held up on whatever machines are depending on the faulty line for power. Any money spent in eliminating as many weak links in the power system as possible is money spent to good advantage and is sure to pay a good dividend in the long run.

Considering details for a moment, when making splices in light and power wiring, the workman usually uses a blowtorch for soldering the joints, which are heated by playing the flame directly onto them. This heats the wire for a considerable distance back in the conduit and is likely to damage the insulation if extreme care is not taken to avoid it. Very often failures in wiring can be traced directly to this cause. It is almost always necessary to have splices in junction boxes and the methods of doing this shown in Fig. 1, which I have used for several years, have been found to be very satisfactory and dependable in every way.

A splice made by soldering on lugs and bolting them together is shown at *A*. Lockwashers are placed under the nuts to keep them from working loose. Diagram *B* shows how to make the splice by twisting the wires together in what is known as a pigtail splice, which is most suitable for small power and light wiring. To solder the splice, a pot of molten solder is raised up until the wires dip into it, and then lowered. Most likely a thick coat of solder will stick to the splice, which will indicate that the joint is not hot enough. The pot is raised and lowered until the solder runs off freely, leaving a very fine coat, with no lumps or drops hanging from the wire.

The method shown in *A* has some advantages that *B* does not possess. For example, the splice is easily made without any danger of damaging the insulation, and it is very convenient in case a section of the conduit has to be moved to make room for new machinery or during alterations, as the connections can be unbolted so that it is not necessary to untwist the wires. This method of making a splice is also a great aid when trouble develops, as it can quickly be located by unbolting the splices so as to break the circuit up into sections and thus permit each section to be tested separately. When the trouble is located and repaired, the splices that were taken apart can be quickly rejoined.

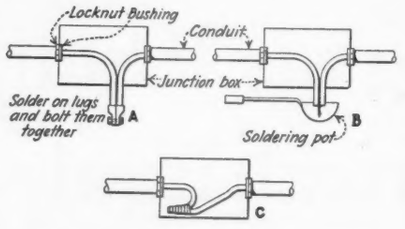


Fig. 1—With these two methods of making splices in junction boxes, there is little danger of overheating the insulation.

In *A*, lugs have been soldered on the ends of the wires, and then bolted together. With this arrangement it is easy to sectionalize or open up feeder circuits. When the conductors are not too large, a pigtail splice may be made and the joint soldered by dipping it in molten solder, as shown in *B*. After the splices have been made, by either method, they are taped and the conductors bent back into the box, as in *C*.

When a blowtorch is played on a splice it takes a considerable length of time for the wire to get hot enough to melt the solder. While the wire is heating up slowly, the heat follows the wire back under the insulation. Nine chances to one, the rubber insulation is well baked back into the conduit, and after the splice has cooled any attempt to move it will crack the insulation.

When making a splice as shown in either *A* or *B* of Fig. 1, it is made near one end of the junction box and then after taping the splice well, it is bent back into the junction box so that the cover can be closed. Only one wire is shown spliced in the illustration, so as to indicate the method more clearly.

Feeder Lines

Another objection to running only one or two long feeder lines and splicing in at a junction box wherever a motor is to be located is that the motors driving different machines will be on the same feeder line and if trouble develops on the feeder, or the main circuit breaker trips out for any reason, it may shut down several machines, instead of one. Any trouble that develops in an electrical system is bad enough without having it multiply by spreading to several machines and the time spent in planning a system such that minor troubles can not spread very far into it is well spent.

It is fairly common practice to run one main feeder to several panel boxes built up out of busbars, knife switches and fuses; sometimes no switches are used—only fuse block cutouts. This method also has some disadvantages, among the most important of which is that if anything goes wrong with one of these panel boxes it may hold up production in the entire plant. Also, there are so many live parts exposed when the cover is opened that it is dangerous to the operators and maintenance men. Again, it is easy to cause a short-circuit, or pull the wrong fuse, when changing a blown one. About the only advantage that such panel boxes have is that they take up only a small space.

The panel box shown in Fig. 2 was built up of enclosed safety switches for the purpose of overcoming these objectionable disadvantages, and has measured up to all that was expected of it, by reducing accidents and delays and speeding up the clearing of any troubles that do occur.

As will be seen, it is built in two separate sections, one part comprising the frame for mounting the switches on, the other being an enclosure or distribution box for the busbars from which power is distributed from the main feeder to the group of safety switches. That part of the box on which the switches are mounted is built out of T or angle iron and mounted on a piece of channel iron. On the upright framework is mounted a sheet of No. 14 gage

iron; the safety switches are mounted on this. The dimensions of such a panel box will depend entirely on the size and number of switches required. Fig. 2 shows the correct dimensions for a box mounting nine 60-amp., 500-volt safety switches.

The distribution box shown mounted on top of the panel box framework is constructed of No. 14 gage sheet iron and contains the busbars which are mounted in it on slate bases that have slots sawed in them to hold the busbars in place, so that they cannot move around or cause a short-circuit. The busbars are made long enough to come within about 6 in. of each end of the distribution box.

The main power line feeder is run in conduit from the switchboard to the distribution box and terminal lugs are soldered onto the wires and then bolted to the busbars. Short lengths of conduit (short nipples are used for switches on the top row) run from the top of each safety switch into the bottom of the distribution box. These conduits contain the wiring for the switches, which is tapped onto the top terminals of the switches and onto the busbars through terminal lugs which are soldered onto the wires and fastened with brass machine screws, holes for which are drilled and tapped in the busbars.

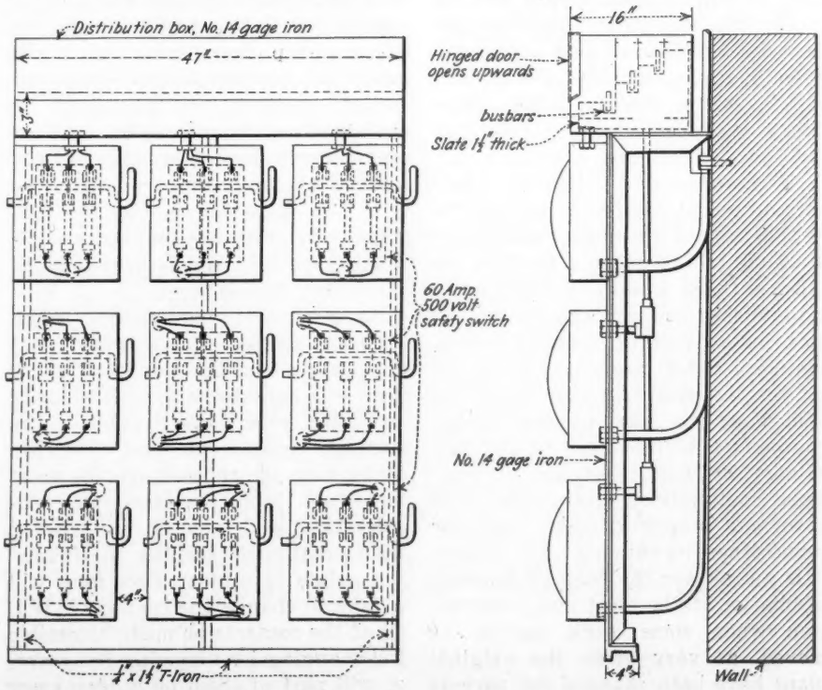
By connecting the top terminals of the safety switches onto the busbars the fuses can be made dead by pulling the switches, and can then be changed without any danger of coming in contact with live parts, which is a good safety measure in protecting the operators or maintenance men who will be called upon to change them. To provide for the possibility of someone not pulling the switch before opening the door to change the fuses, the switches should be so constructed that they cannot be opened until the switch has been pulled. They should be provided with a key so that they can be opened for tests and inspection whenever it is desired to do so without opening the switch.

The distribution box containing the live busbars is mounted with the front side and door on a line with the front side of the switches, as shown in the side view in Fig. 2. It is necessary to leave only enough room between the top of the upper row of safety switches and the bottom of the distribution box to allow the covers of the switches to be opened and closed, which will usually be less than 1 in., depending on the size and type of switch.

When building up the panel box, it is advisable in most cases to make it a little larger than is needed at present, if it is thought that it will be necessary to take care of future installations of motors. For example, leave enough space on the bottom or sides to mount another row of switches when needed.

Such a type of panel box has a good many advantages to its credit. First, it provides independent circuits for the motors, which can be isolated into groups for different machines. Second, it is accessible, which makes it safe, allowing fuses to be changed without danger, and repairs to be easily made. Third, there are no splices, such as are made in junction boxes, which insures a better installation, resulting in less service delays and interruptions. Fourth, this panel box guards against the dangers of a short-circuit, as all circuits are well separated, and there is no danger of coming in contact with the main live busbars when working on the switches and changing fuses. Fifth, new sections can be added onto the sides of the panel box as they are needed, and the switches can be changed to a larger size if necessary when changing to a larger motor.

Fig. 2—Here is a panel box that combines safety with accessibility. The safety switches are mounted on a sheet of No. 14 gage iron which is fastened to a framework of 14-in. x 1½-in. T iron. The busbars from which power is distributed to the safety switches are enclosed in a sheet-iron box placed above the switch rack and mounted, as shown, on slate bases screwed to the bottom of the box by ⅜-in. capscrews driven into Ackerman Johnson expanding screw anchors.



Switch and Control Units

Fig. 3 shows a good method of installing starting boxes and switches as a single unit, in places where it is not necessary to build up a panel box. The framework is built out of ¼-in. x 1½-in. angle iron. A framework of this kind makes a good, substantial installation and has the advantage of making it easy to change a switch or starter. Another good point is that the starter and switches can be mounted as a unit in the shop and set up very easily when wanted. Also, in case of failure of a starter or switch, or the installation of a larger-sized motor to meet an emergency, a spare unit can be quickly set up.

Sometimes it will be found of advantage to mount a number of motor starters and switches on one panel when it is desired to control several motors from one point. In this case a panel similar to the one shown in Fig. 2, with the distribution box mounted on top of the starter rack, may be made up. The framework should be constructed of angle iron, the size depending on the size and number of starters required. An installation of this kind looks neat, and will speed up inspection and the changing of contacts.

I once had occasion to put in a new installation of starters and motors in a plant in which part of the power was generated and the rest purchased. As much load as possible

was carried on the generating system, and the rest thrown onto purchased power. The load was regulated by double-throw switches. Fig. 4 shows how the switches and starters were mounted on a starter rack, as it was desired to control several motors from one point. The double buses are shown mounted on top of the starter rack with one bus above the other, and separated by two insulators, in order to keep the rack as near the wall as possible. As it was desired to fuse both lines ahead of the starter, double-throw, non-fused safety switches were used, and the fuses were mounted in a cabinet below the switch. This arrangement saved one set of fuses, and had the additional advantage that the fuses could be killed by opening the switch. By building this type of a distribution panel considerable conduit, wiring and labor was saved by not having to run two sources of power lines to widely scattered motor starters.

(3) *Distribution Centers*—Selecting the most economical centers of distribution requires considerable study and forethought in order to plan and lay them out correctly, keeping the following points in mind: Will future installations of machines make it necessary to move them later on? Is it cheaper to run the main feeders up close to where the motors are to be set, and run short lines to them, or stop the main feeders farther away and have longer small lines running to each motor? This can be answered satisfactorily only by figuring the cost of the conduit, wire, labor, etc., for the small lines and comparing it with the cost of the large line.

(4) *Number of Feeders*—A decision as to the number of main feeder lines to run will depend mostly on the size of the contemplated installation, and how it is planned to group the machines. If it is decided that the motors for each machine are to be kept independent from the rest, one main feeder line should be run to take care of the individual motors for each machine. This applies, of course, only to machines having several motors. It will usually be satisfactory to run a main feeder line to take care of several machines.

(5) *Excess Capacity*—The amount of over-capacity to allot to each feeder line will depend on whether there is likely to be any future installations of machinery that will have more or larger motors to be tapped off the feeder, or whether motors will be changed to larger sizes later on. In my experience I have found that it pays to install a main feeder with 25 to 50 per cent over-capacity to take care of future installations of motors. When the center of distribution has been finally selected and the total horsepower load of the motors to be tapped off has been determined, the size of the main feeder line can then be decided on.

(6) *Use of Conduit*—The question of whether to put all wiring in conduit is a big one. From the standpoint of reliability, all small wiring should be run in conduit, for this makes a good, safe layout and when properly installed it will require very little maintenance expense. Also, there is not much danger of shutdowns due to the wiring being damaged. But when large main feeder lines, above 500,000 cir.mil size, are involved, they can in most cases be run as open wiring well up out of the way, and this arrangement will prove to be just as reliable if not more so than the use of conduit, in which case the heavy wires have to be forced into conduit fittings and junction boxes.

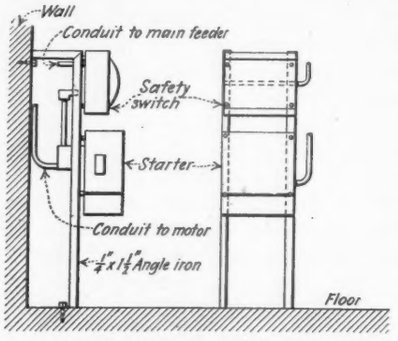


Fig. 3—Mounting starters and switches as a unit facilitates installation and replacements.

(7) *Location of Equipment*—Placing equipment so that it will not be in the way of the other machinery is of vital importance. Besides the expense there is nothing that is any more disheartening than to have a nice installation of starting boxes, switches, panel boxes and so on all set up and ready to run, and then find, when you start to congratulate yourself on being ahead of the machinery erectors, that one of your prize installations has to be torn down and moved to make room for some other machinery. Of course, it is not always the fault of the man in charge of the electrical construction when some work has to be moved, as very often the original plans have been changed for various reasons. But any effort put forth in avoiding such happenings is certainly worth while. The man in charge of the electrical construction should have blueprints of all layouts of the piping, machines, sprinkler system, and the like, and study them well before locating the electrical equipment.

(8) *Selection of Equipment*—The question of purchasing equipment that will give the best service and require the least amount of maintenance work when installed is a big one, and requires careful study.

In many cases a list of needed equipment is submitted to the different manufacturers for bids, without a plain statement of the specifications that must be met as to quality of materials, or the exact conditions under which the equipment will have to operate. Again, unless care is taken, there is a tendency to award the order to the manufacturer who has submitted the lowest bid, without any consideration of the quality of the equipment, the cost of upkeep after it is installed, or whether it fully meets the specifications and requirements.

True enough, the first cost of a new installation is dreaded, for it means spending hard-earned money, but that money is spent for the purpose of making more with it and when the installation is completed the only way to do this is to keep the wheels turning day in and day out. The cost of maintenance is certainly worth careful consideration.

There is, after all, comparatively little difference between the cost of a good installation and that of a so-called cheap installation that will prove to be unreliable when installed: certainly not enough to be the deciding factor. The cost of maintenance and repairs may be only a small amount, compared with the time lost in production by the machines when they are shut down while repairs are being made to the equipment that drives them.

As a general rule motors, when properly applied and installed, and given a reasonable amount of attention, will operate very satisfactorily and give very little trouble. The starting equipment and switches controlling the motors are the most important items to take into consideration and should be selected with great care, keeping the following points in mind: How long will it take to change the contacts? Will all of the contacts be made accessible for changing by removing the cover, or will part of them be hidden away

behind coils, and the like, so that the starter will have to be disconnected and taken apart to get at them? Will the parts be interchangeable for three or four different horsepower ratings, so as to reduce the number of spare parts to a minimum?

It is not uncommon for a small controller or switch to be part of the drive for an important machine that is producing from $100 to $200 worth of finished products per hour. With this fact in mind, it can readily be seen that every minute is precious and counts while the controller is out of service for repairs.

A piece of starting equipment that has all contacts in plain view and easy to get at when the cover is removed may cost $100, while another one of the same capacity but having a part of its contacts in an inaccessible place may cost only $85. It is very evident that the latter type is going to take more time in locating troubles and making repairs and adjustments, and the extra maintenance cost will soon amount to more than the difference in cost between the two starters, to say nothing about the time lost in production.

Standardization of Equipment

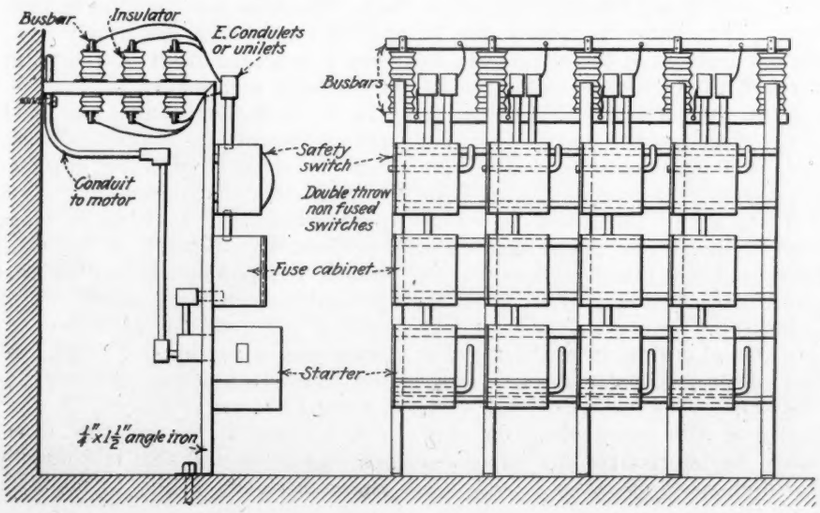
There is a strong tendency today to standardize equipment, which is a fine thing as far as it goes. The main advantage is that we will have to keep fewer spares and less repair parts in stock for emergencies. Can we standardize completely on equipment and keep up with the steady march of progress? Any answer to this question must be qualified. We can standardize on one particular manufacturer's equipment, refusing to consider all other makes, whether good or bad, and fool ourselves into thinking that we will be carrying less spares and repair parts. It has been my experience, however, that anyone who standardized on one particular line of electrical equipment ten years ago, and has bought nothing else since, now has a pretty good collection of repair parts, due to the manufacturer whose equipment he has standardized on, changing the type and construction of his equipment three or four times in trying to make improvements. In some cases the equipment has been improved, and in others a backward step may have been taken. I have had four 5-hp., 900-r.p.m. motors of the same make in my care, each of which used a different size and type of bearing. Can we standardize on equipment like this and keep the stock of repair parts low? Should we turn another salesman away, who has another motor or whatnot which may be as good or better than we are using, with the sole remark that we have standardized on a particular manufacturer's line of equipment, when the spare parts on hand may not fit the next item you purchase from him?

Standardization is desirable if it can be carried out to advantage. We all want the best equipment that we can possibly get, and the only way to know which is best is to try out the new lines of equipment as they are developed. I do not mean by this that we should buy every new piece of equipment that is put on the market. However, if a new type of switch or controller is developed, it will pay to look it over. If it appears to be a good design and we cannot find any reason why we do not want it, except that we have already standardized on another line, it will be well to purchase one of them, install it and give it a fair trial in service. If it proves to be any better than the ones already in use, then the next large new installation of equipment should be of this type.

I know of one particular new installation for which a large number of new switches were purchased on the basis of the bids received, and proved to be a failure in every way, by not standing up on the operating voltage and being very awkward to work on. This was a sad and costly experience that could have been avoided by a better knowledge of equipment, gained by trying out the new designs as they were developed.

Fig. 4—Method of installing two sets of busbars on separate sources of supply with safety switches, fuse cabinets, and starters.

One set of buses is fed from the plant generating system, while the other distributes purchased energy. It was desired to control a number of motors from one point and in order to facilitate adjustment of the load so that the plant generator can be kept fully loaded, double-throw switches were used, which makes it possible to operate any desired number of motors on generated or purchased energy.



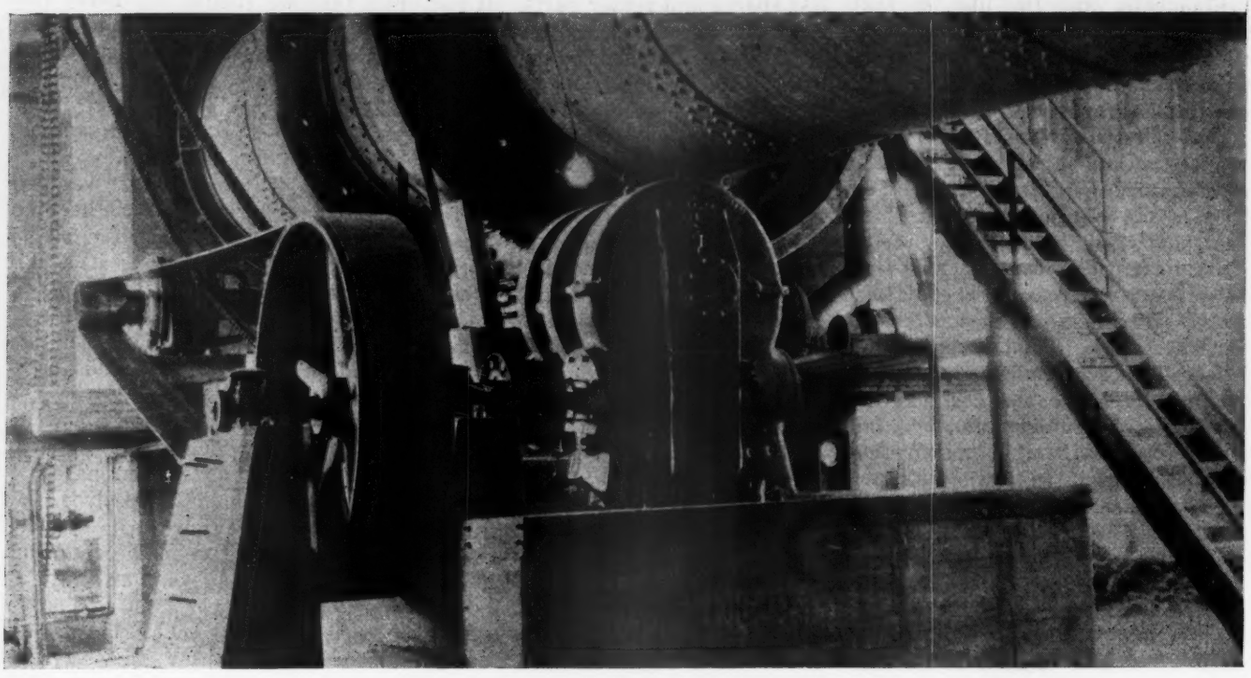
Testing New Installation

After an installation is completed and the motors are in operation they should be tested with a wattmeter, preferably of the curve-drawing type, so that the test records can be preserved for future use. In most cases many of the motors will be found to be operating overloaded, while some will be underloaded. They should then be changed and rearranged, so that they will be operating as nearly fully loaded as possible. This will improve the power factor, which will increase the efficiency and improve operating conditions, by insuring better voltage regulation. It will also decrease the load on the generators.

Testing of the motors can be done much more cheaply and quickly if several of the safety switches are mounted together on a common panel box, so that it is not necessary to move the current and potential transformers and other testing equipment to a new location every time a motor is tested.

Test sockets can be obtained from the switch manufacturers for use on all switches controlling important drives that cannot be shut down to cut in the meter. Current transformers of the split-core type will also be found very useful and handy.

When the installation is completed, the name of the drive that each switch controls should be stenciled on the cover, to prevent mistakes when pulling the switches.



An example of a compact installation of a worm drive, connected to a rock dryer in a cement plant.

Any drive equipment in service like this is subjected to a shifting and impact load due to the rolling of the contents of the dryer. Notice the outboard bearing to take the radial load of the belt on the worm bearing.

Use of Worm Reduction Units *for Power Transmission*

By G. H. ACKER

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UNTIL within recent years technical schools have taught, and many engineers and designers have believed, that worm gearing was a rather inefficient means of transmitting power, but that for providing a high ratio of reduction in a compact mechanism its use was sometimes advisable. This teaching was based on the sad experience of many users of worm gearing because such gearing as was available at that time was hopelessly inefficient and generally unsatisfactory. As a result, most engineering handbooks, as well as the literature published by many gear manufacturers, treated worm gearing as a mechanism that could be operated, at best inefficiently, only at slow speeds and could not be used to transmit heavy continuous loads. Unfortunately many of the texts and reference books for engineers and operating men have not been brought up to date on the use of worms for speed reduction and power transmission.

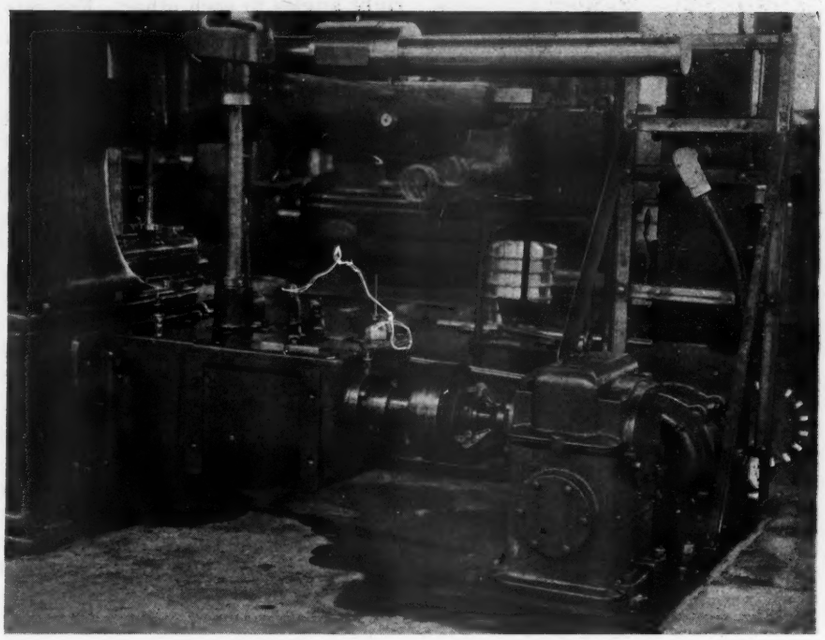
At present, however, worm gearing is emerging from the shadows of of its former reputation and is taking its place as a real factor in the solution of power transmission problems. The change is largely due to the development of the worm gear as a result of its use in motor trucks for rear axle drives.

The worm gear of today is similar to the old style worm gearing in that it consists of a worm meshing with a gear, but at this point the similarity ceases. In performance the two types are utterly different; the superiority of the gear of today is due to the improvements in tooth and thread design, in addition to the use of proper materials and workmanship. The old cast-iron worm and gear with cast teeth would, obviously, be impractical and impossible for high-speed operation.

Some remarkable performances of worm-gear speed reduction units are on record. In one installation, for instance, an induced draft fan was driven through a worm-gear reduction unit by means of a 100-hp., 3,200-r.p.m. steam turbine. The reduction ratio in the unit was $10\frac{3}{4}$ to 1. The drive was installed in 1920 and ran continuously for nearly 4 yr., when a rearrangement of the plant necessitated a shutdown.

It is immediately apparent that here is something quite different from the old type of worm gearing. First, in this installation the worm speed was about four times what was formerly thought to be safe. Second, the power transmitted was reasonably high for a single set of gearing. Third, the drive was in continuous operation. Fourth, the unit showed an actual efficiency under test of 94 per cent.

A feature of the modern worm gear reduction unit that is especially important is its ability to maintain



Here the worm reduction unit is direct-connected to a boring mill through a clutch.

The angle-iron framework for supporting the starting equipment is built over the motor not only for protection, but also to economize on floor space. The right-angle drive also saves floor space.

its high efficiency throughout its life. On some units the worm threads are hardened and ground and the mating gear is made of high-grade phosphorized bronze. Any wear must, therefore, occur on the gear teeth and, since these teeth are cut by the hobbing method, the action of the worm threads on the teeth is exactly the same as the hob that generated the original tooth contour. It follows, therefore, that even after considerable wear has occurred, and this should be retarded by adequate lubrication, the meshing surfaces bear exactly the same relation as at first. This accounts for the maintained efficiency and is, moreover, a feature not found in any other form of gearing.

The amount of wear that occurs in a speed reduction unit is also important. For example, the record of a mechanical gas producer with a worm-gear drive, which is shown in an accompanying illustration, is interesting. In commenting on the performance of this drive the builder of the machine made the following statement: "The first producer with the worm-gear drive was put into service in August, 1922. A year and a half later it was taken down, examined and checked carefully. There was absolutely no indication of any kind of wear on the worms or gears. It had been running 24 hr. per day and seven days a week, a service which was the equivalent of about 5 yr. of ordinary 8 hr. per day operation. We feel confident that the worm gear drive will give ten years' service under these extreme conditions without any repairs."

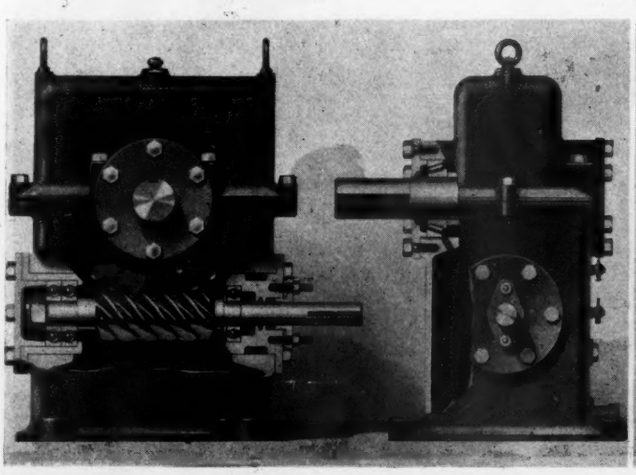
This producer drive is of the double-reduction design, in which two worms and two gears are incorporated. The total reduction between the motor and the bevel pinion is 528 to 1 and the poker and ash dump are driven from a crank attached to the first gear shaft. The compactness and neatness of the drive will be noted from the illustration.

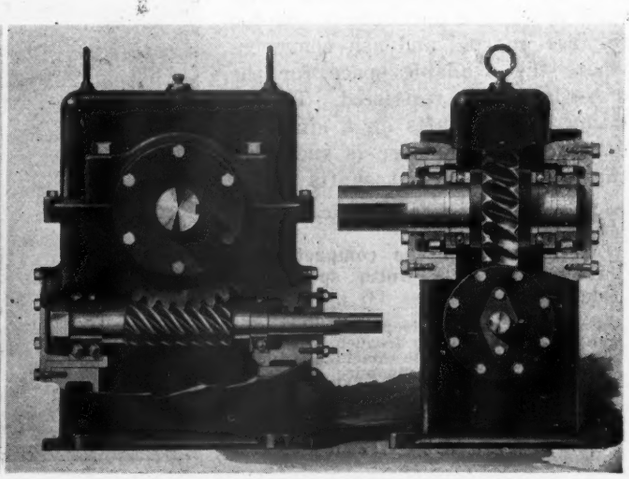
One of the first applications of the automotive type of worm gearing to an industrial drive was in connection with a mechanism for operating open-hearth furnace doors in a large steel plant. The special drive built for this purpose is shown on page 8. A total of 50 units of this same type were installed in 1917. The service is intermittent and not particularly severe, but the satisfactory results have led to the application of worm gearing to a great variety of other drives in the leading steel plants. Since these drives were installed the design of the units has been much improved.

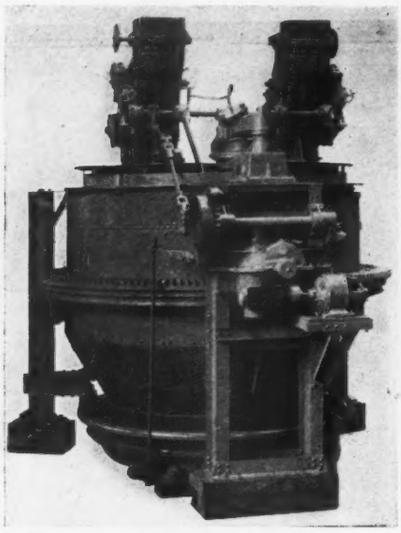
So far as severity of service is concerned, the drive illustrated at the beginning of this article offers quite a contrast to the preceding installation. The reduction unit in this case

Bearing construction of two types of worm reducers.

The worm shaft in both units is supported on a double-row ball bearing at the back and a single row of balls at the front. In each of these cases the provision for preventing oil working out around the worm shaft is slightly different, as may be seen from the illustrations. The gear bearing in the unit at the left is designed for a torque load and is supported on tapered roller bearings. The worm shaft in the unit at the right is designed to carry not only the torque, but also a radial load due to a belt and pulley or a gear and pinion drive, which gives torque as well as a side pull. In this case the shaft is supported on roller bearings and ball thrust bearings. Many users of reducers fail to differentiate between the torque and radial or side load and its effect upon the bearings.







This double-reduction worm unit serves a dual purpose.

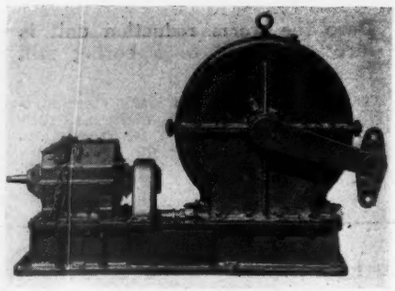
Where an extremely large reduction is desirable, or where different parts of the equipment operate at different speeds, double-reduction units are frequently used where one speed is taken off at the first reduction and another lower speed is taken off at the second reduction as in this case.

is connected in the drive of a large rock dryer in a cement mill. The dryer is 8 ft. in diameter by 80 ft. long and rather dwarfs the reduction unit, although the over-all height of the unit is nearly 6 ft. In addition to the fact that the horsepower transmitted is high and the operation continuous, the gearing is subjected to severe impacts and shocks due to the characteristics of the load. Other applications of worm gear reduction units to kiln, dryer and cooler service have been made with the motor direct-connected to the worm shaft and have proved equally satisfactory. The unit illustrated is transmitting 85 hp. with an 8.4 to 1 reduction ratio.

For conveyor and elevator drives the outstanding advantage of the worm gear reduction unit is its compactness. As it can be installed in a small space it is particularly adapted for use on coal and ash conveyors where the available space for the drive is usually restricted. The relation of the shafts on a single-reduction worm reducer is such that the input and output shafts are at right angles to each other. For this reason the worm and its drive can be installed alongside and parallel to a conveyor, which is more economical of space than if the drive had to be installed at a right angle to the line of the conveyor and extend out into the aisle. The gear shaft of the standard worm unit can be extended either to the right or to the left of the housing, or on both sides. The worm is so mounted that it can be rotated in either direction.

The use of high-grade, anti-friction bearings on the two shafts of industrial worm-gear speed reduction units has been an important factor in their successful performance. A standard drive, in which the worm shaft is mounted on ball bearings and the gear shaft on tapered roller bearings, is shown in the accompanying illustration at the left at the bottom of page 7 and represents a high development in the modern worm gear reduction unit.

The use of anti-friction bearings, for both shafts, not only increases the over-all efficiency of the drive, but also adds to the durability of the mechanism. Worm gearing, in order to maintain its efficiency over a long period, must be held accurately in alignment. For long life and reliable, efficient operation, the prevention of bearing wear is more necessary than the prevention of gear wear. The amount of bearing wear which might be tolerated with other types of gearing is likely to cause serious deterioration in a worm gear drive. The use of anti-friction bearings, however, obviates this difficulty entirely, and provides the additional advantages of easy and accurate replacement in case of unavoidable accidents or breakdowns.



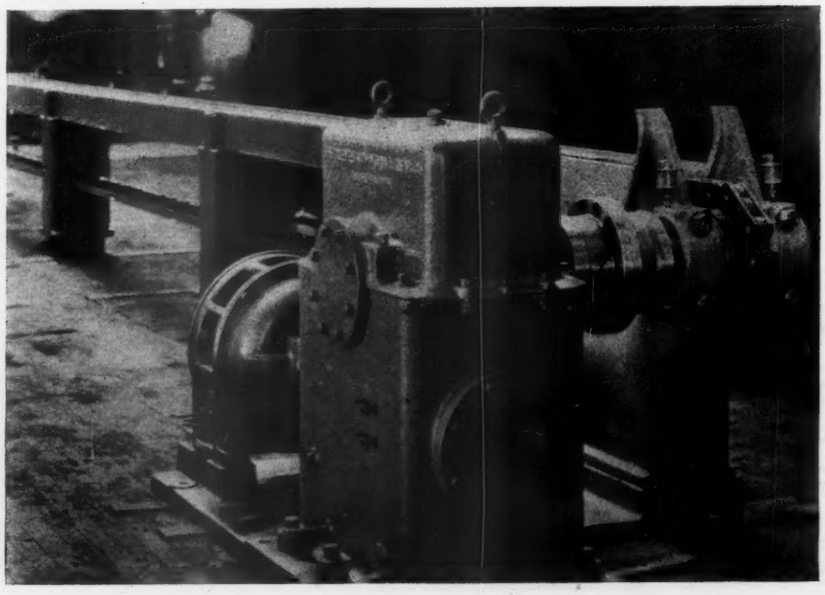
This is a different type of double-reduction unit.

The motor is connected through a gear drive to the worm shaft for the first reduction. The second or worm reduction is connected to an open hearth furnace door opener.

Many users of speed reduction units do not realize the importance of the two types of loads which may be applied to the shafts and bearings. The first is a torque load such as is applied by a motor driving in a straight line through a flexible coupling. The more severe service comes from an overhung load such as results from a belt or gear on the shaft, which gives not only the torque but also a side pull or radial load. It is this side load which is likely to cause trouble and is frequently not given sufficient consideration by the user.

Even in the case of a reduction unit designed to carry an overhung load on the gear shaft, the use of anti-friction bearings has been found distinctly advantageous. A reduction unit designed for this type of service is shown in the illustration at the right at the bottom of page 7. The gear shaft of this unit is

(Please turn to page 11)



An example of the compact arrangement of a worm speed-reducer drive.

Because a worm gives a right-angle drive, the motor can frequently be installed alongside the machine which it drives and so economize on floor space. Here the worm is connected to a wire-drawing bench through a Francke flexible coupling. The worm reducer gives a 22½ to 1 reduction from a 720-r.p.m., 25-hp. motor.

JAMES B. HOLSTON *answers the question*

"How High Should I Raise Our Power Factor?"

PREVIOUS ARTICLES of this series have appeared in the July, August and September issues. In these articles power factor was discussed from the standpoints of the cause and nature of this condition, its effects in creating undesirable operating conditions and increasing the cost of the electrical energy consumed, and the practical methods of correcting it, both with and without the use of special equipment designed for this purpose. In this article Mr. Holston shows the considerations involved in determining how high the power factor of an industrial plant can profitably be raised.

WHEN making a study of an industrial plant installation, the first step is to determine whether or not power factor correction will be profitable; then the most economical method of correcting power factor must be selected. The final consideration is how far it will pay to go in the correction program. That phase of the problem will be discussed in this article.

As with most problems of an engineering nature, all of the factors and conditions that have a bearing on the problem require careful consideration, as the correct solution will be found only when proper disposal has been made of the particular difficulties that arise in every case.

The first step in the power factor correction program is to determine whether or not existing equipment can be operated at a better power factor. Any results in the way of raising power factor that may be obtained by rearrangement of the driven machines, or motors, will usually more than pay for the cost of making the changes. However, it is seldom possible to raise the power factor of an installation above 80 per cent without using one or more of the various types of corrective equipment designed for this purpose. In the article in the September issue these types were listed as follows:

(1) Synchronous motors.
(2) Fynn-Weichsel motors.
(3) Static condensers.
(4) Synchronous condensers.

Although all four types have their particular applications, it is probable that in the majority of cases one or the other of the first two types of equipment offers the most satisfactory means of obtaining the correction needed. Occasionally, however, it is found that corrective motors will not raise the power factor quite high enough, and the added expense of condensers to be used in addition to the motors may be justified. In cases of this kind it must be remembered that the added investment is justified only when the *increased* saving made possible thereby warrants it. In other words, the total saving due to power factor correction should not be used to justify the total investment in corrective equipment; only the additional saving made possible by the use of extra correction equipment can be used as justification for the extra expenditure involved.

What High Power Factor Does

In order to make clear what follows, it may be well to answer again the question, What are the benefits of power factor correction? Briefly, they are: better voltage regulation; lower line losses; discounts on power bills. Specifically, better voltage regulation throughout the plant means more efficient operation of all motors as well as better speed characteristics; it also means better lighting conditions. Lower line losses mean less power consumption, which, with the power factor discount, gives a direct reduction in the power bill.

The saving in line losses depends upon the type of corrective equipment installed. Reference to the line diagram in Fig. 1 will help to make the following discussion clearer. Power factor correction by the power company usually is made on their own portion of the distribution system, section *A*, which means that no benefit accrues to the consumers except better voltage regulation on the main feeder. Power factor by the consumer can, on the other hand, be made in one or more of four places: on the primary, or high-voltage side of the transformer bank; on the secondary, or low-voltage side; at the distribution centers; or on the individual circuits. Obviously the greatest benefits are derived from correction on the individual circuits, since the lower current flowing, by reason of the high power factor, results in a reduction of line losses throughout the system. Frequently, a single unit of corrective apparatus at each local distribution center will afford the most satisfactory means of power factor correction. Unity power factor from the local centers back to the meters is a very satisfactory condition.

Some idea of the relative magnitude of system losses and the savings resulting from power factor correction may be gained from a consideration of the laws governing line currents, losses, and power factor.

In the first place, system losses vary directly as the current squared; current, in turn, is inversely proportional to the power factor; therefore, the losses vary inversely as power factor squared. In a system designed to operate with 5 per cent line loss at 85 per cent power factor, the loss at 60 per cent power factor is found as follows:

$.05 \times (85)^2 \div (60)^2 = 10.03$ per cent

Furthermore, the loss at 100 per cent power factor is:

$.05 \times (85)^2 \div (100)^2 = 3.61$ per cent

In any system, raising the power factor from 60 per cent to 100 per cent will pay a return of 10.00 per cent minus 3.61, or 6.42 per cent of the total energy consumed. If a plant uses 100,000 kw.-hr. per month at a cost of 2 cents per kw.-hr., and the power factor is raised through-

out the system from 60 per cent to 100 per cent, the saving will be 100,000 × 6.42 per cent × 0.02, or $128.40 each month. This amounts to $1,540.80 in a year. Capitalized at 15 per cent this saving represents an investment of over $10,000.

Of course, it must be noted that correction throughout the system is necessary before such savings are possible. A quantitative determination of the savings resulting from correction, when made at the several possible points of the system, is a laborious process involving, as it does, wire sizes, line drops, currents, load factors, and other variables. The value of the results of such calculations, in view of the work required, is doubtful. It is sufficient to say that if the choice lies between two or more of the several places where correction may be applied, the one farthest in the system should be chosen.

Limits of Correction

Having given due regard to the expediency of the various methods and the location of the apparatus used, we come to the final question of just how far to go with the correction program. The problem resolves itself into a simple one of return per dollar of investment.

As an example, let us consider the following case: A consumer using 100,000 kw.-hr. per month and having a demand of 450 kw. at 65 per cent power factor is billed for power in accordance with the rate shown in Fig. 2. In Table I the left-hand column shows the power factor of the installation after corrective equipment has been installed. Column 6 gives the cost of corrective motors required for the corresponding power factors. The motor sizes convenient to change to the corrective type are 50, 75, 100, and 150 hp., and Fynn-Weichsel motor prices are used, although the data in general apply to any type of synchronous motor. The installation cost has been omitted from consideration as this is an old installation and the value of the motors removed more than offsets the cost

Cost of Raising Power Factor, and Yearly Savings with Different Types of Corrective Equipment

TABLE I

(1) Final Power Factor, Per Cent	(2) R-Kva. Required to Raise from 65 Per Cent Power Factor	(3) Power Cost per Month	(4) Saving per Month	(5) Saving per Year	(6) Motor Cost	(7) Depreciation 15 Per Cent	(8) Operating Cost per Year	(9) Net Yearly Saving	(10) No. Years to Write Off Investment	(11) Yearly Return per Dollar per Year Invested
65	...	$2,500	....	.....	.....	.....	(Not included)	.....	....	.....
75	130	2,300	$200	$2,400	$1,888	$282		$2,118	.89	$1.12
85	252	2,160	340	4,080	4,348	650		3,430	1.27	.79
90	312	2,100	400	4,800	4,700	705		4,005	1.17	.85
95	383	2,050	450	5,400	5,930	890		4,510	1.31	.76
100	522	2,000	500	6,000	8,669	1,310		4,690	1.85	.54

TABLE II

(1) Final Power Factor, Per Cent	(2) R-Kva. Required to Raise from 65 Per Cent Power Factor	(3) Power Cost per Month	(4) Saving per Month	(5) Saving per Year	(6) Static Condenser Cost Installed	(7) Depreciation 15 Per Cent	(8) Operating Cost per Year	(9) Net Yearly Saving	(10) No. Years to Write Off Investment	(11) Yearly Return per Dollar per Year Invested
65	...	$2,500	....	.....	.....	....	(Not included)	.....	....	.....
75	130	2,300	$200	$2,400	$3,900	$ 585		$1,815	2.15	$0.465
85	252	2,160	340	4,080	7,560	1,130		2,950	2.56	.390
90	312	2,100	400	4,800	9,360	1,400		3,400	2.75	.364
95	383	2,050	450	5,400	11,490	1,725		3,675	3.12	.320
100	522	2,000	500	6,000	15,660	2,340		3,660	4.25	.234

TABLE III

(1) Final Power Factor, Per Cent	(2) R-Kva. Required to Raise from 65 Per Cent Power Factor	(3) Power Cost per Month	(4) Saving per Month	(5) Saving per Year	(6) Synchronous Condenser Cost Installed	(7) Depreciation 15 Per Cent	(8) Operating Cost per Year	(9) Net Yearly Saving	(10) No. Years to Write Off Investment	(11) Yearly Return per Dollar per Year Invested
65	...	$2,500	....	.....	.....	....	.....	.....	....	.....
75	130	2,300	$200	$2,400	$3,000	$450	$828	$1,122	2.67	$0.374
85	252	2,160	340	4,080	4,600	690	1,296	2,094	2.20	.455
90	312	2,100	400	4,800	5,500	825	1,575	2,400	2.30	.437
95	383	2,050	450	5,400	6,000	900	1,907	2,593	2.31	.432
100	522	2,000	500	6,000	7,000	1,050	2,520	2,430	2.88	.347

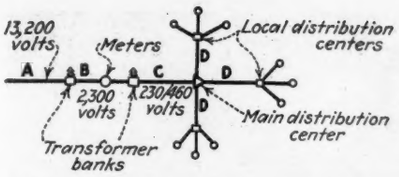


Fig. 1 — Power factor corrective equipment may be applied at any one of several different points in a distribution system.

As may be desired, power factor may be corrected on the high- or low-voltage sides of the transformer bank, at the main distribution centers, or on the individual circuits.

of placing the new ones. Column 10 shows the time required to write off the investment in each case, and Column 11 shows the annual return per dollar invested. It will be seen at once that the increased investment necessary to raise the power factor from 95 per cent to 100 per cent is not justified, since the $2,739 additional investment brings a return of only $180 per year.

This discussion could be carried into further detail if the 15 per cent amortization charge on the corrective motors were compared to the somewhat lower charges against the old induction motors. However, if the induction motors have been in service more than 7 yrs. they have probably been written off the books. Even if they have been in only one year, the 15 per cent charged off can permissibly be deducted from the cost of corrective motors. This may be considered an academic discussion and for the present purposes may be dropped without serious error resulting in the calculations.

Correction by Condensers

Table II shows data on the use of static condensers for power factor correction at the same load as given in Table I. In this table the condenser losses have been neglected, although they will amount to a substantial total if the low-voltage type of condenser is used. If high-voltage condensers are installed the power factor losses will be present throughout the system and the low power factor will extend into the transformer bank. Hence, even with the high-voltage condensers, the losses must be charged against operating cost. It will readily be seen that correction beyond 90 per cent power factor is not justified, as an additional investment of $6,300 would be required to make an additional saving of $260 a year. The returns would be too low to make the investment profitable.

Table III shows the same data covering the use of synchronous condensers. The operating costs, given in column 8, do not include the labor required to operate and maintain the condenser, although this expense will probably be $300 a year or more. In this case it will be seen that correction beyond 95 per cent is not justified.

The data given in Tables I, II, and III are represented graphically in Fig. 3. The return per dollar of investment shown in column 11 is plotted against the power factor given in column 1. In this particular installation synchronous motors prove to be the most economical, the return ranging from somewhat over 100 per cent per year to a minimum of about 50 per cent.

Condensers as an Investment

The returns secured by the use of condensers is sufficient to justify their use although, as has been pointed out, in the case of the static type the cost for correction above 90 per cent cannot be justified, and the synchronous type ceases to be a good investment at 95 per cent correction.

The purpose of this somewhat detailed explanation of the problems connected with the selection of corrective equipment is to show the manner of attacking the problem and to call attention to the more important considerations. It will be obvious that no particular type of corrective apparatus is always best, for each situation is different; it is also quite apparent that care must be exercised to limit the investment in corrective equipment to the most economical point.

Operating men must be prepared

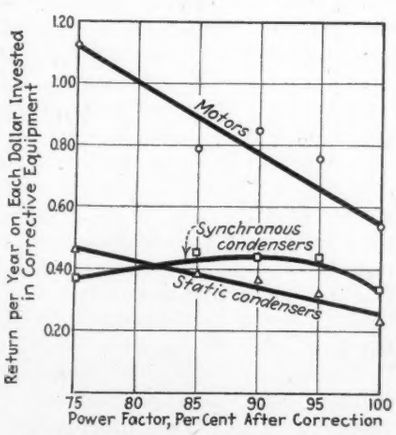


Fig. 3—These curves show the yearly return per dollar invested in the different types of corrective equipment. (See also Tables I, II and III.)

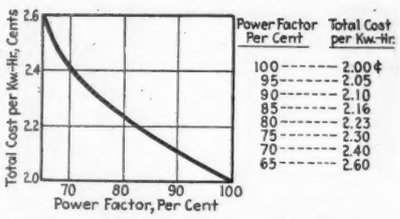


Fig. 2—This shows the relation between power factor and the cost of electrical energy per kilowatt-hour.

to meet the ever-increasing use of the so-called "preferential" power factor rate. And in a new installation—regardless of rates—careful consideration should be given to every factor that makes for operation at a high power factor.

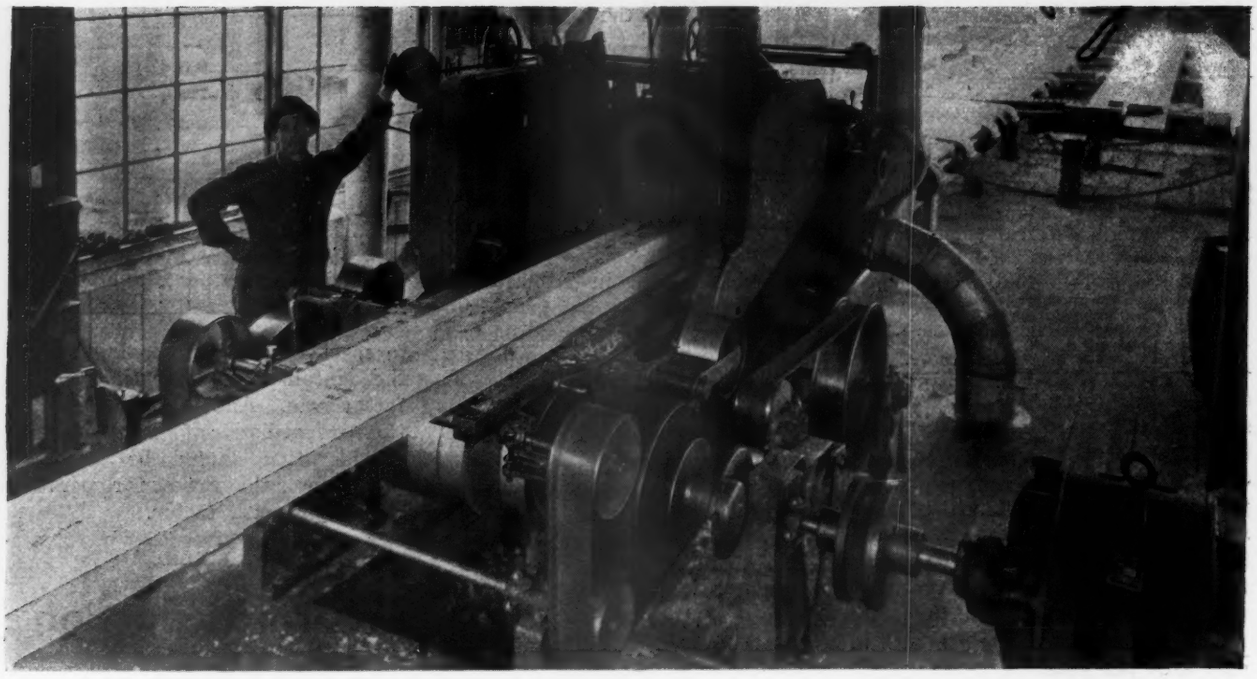
Worm Reduction Units

(Continued from page 8)

exceptionally heavy and high-grade roller and ball bearings are arranged to take the thrusts and radial loads due to an overhung pulley, pinion or sprocket on the gear shaft extension. No outboard bearing is necessary with this unit in order to handle overhung loads and it is therefore particularly adapted for use in cement mills, lumber mills, power plants and for general conveyor and elevator service where space is restricted and large reductions in speed are required.

Worm gear drives are now being used on a great variety of machinery, as for example, the chain draw-bench for wire shown on page 8. Here the heavy chain sprocket is connected to the gear shaft of the worm gear unit through a flexible coupling. Other metal forming machines such as the lighter rolling mills, foil mills, and machine tools such as the horizontal boring mill illustrated, are being driven through worm gearing. In many cases the worm reduction gearing is being incorporated in the design of various machine tools by manufacturers. In addition, many users are modernizing and improving their equipment by the addition of a reduction unit in the drive.

The worm gear unit is readily adaptable for the transmission of power under a great variety of conditions and where suitable it has become an efficient and dependable solution for many difficult power transmission problems.



Woodworking machinery, with its short turns and high speeds, demands a belt combining special flexibility with sufficient strength to afford a firm grip for fasteners.

POINTS TO REMEMBER

When Using

Rubber Transmission Belting

By C. F. CONNER
Engineer, Mechanical Sales Dept., The B. F. Goodrich Rubber Co., Akron, Ohio

RUBBER belting is distinctly an American development and its manufacture and application have progressed much further in this country than in any other. Government statistics show that the production of rubber transmission belting in this country, in spite of the increased use of motor drives, has been growing in the past few years. Rubber transmission belting has been in demand chiefly in the paper, mining, lumber and other basic-material industries where heavy machinery, intermittent loads, exposure to moisture and dust, and other adverse conditions have submitted it to the severest tests.

The higher qualities of rubber belting made today are much better able to withstand the deteriorating effects of age, heat, moisture and other influences than were the belts made a decade ago. The resistance to moisture afforded by rubber belting is well known, but its increased use is due not only to this quality, but also to its freedom from variations in length. The value of rubber as a filler for cotton fabric is due to its sealing the strands of cotton so completely that a rubber belt is comparatively free from any tendency to shrink and elongate with changes in humidity.

Among the more improved types of rubber belting are constructions in which the natural stretch of the cotton duck is largely removed in manufacture so that the completed belt is capable of transmitting heavy power loads with a minimum of take-up and adjustment to keep the belt tight on the pulleys. This has been reflected in a low maintenance cost and a steady transmission of power, so that in many applications the rubber belt has demonstrated a reliable capacity for service in addition to its advantageous first cost. Another distinctive feature of rubber belting is its capacity to retain its flexibility without treatment. Rubber belts require little or no breaking in and, when properly proportioned to the horsepower of the drive, seldom require the use of belt dressing.

The buyer will find it worth while to keep informed on improved belting constructions offered from time to time and to bear in mind that the inventive and engineering talent in the rubber industry, which for many years was concentrated on the development of the automobile tire, is now being applied also to the improvement of belting and other rubber products for industrial use, so that some important developments may logically be looked for at any time.

One important improvement already made is in the manufacture of factory-made endless belts. Rubber belts can now be built endless without splices or joints and have practically equal strength in all parts. The chief advantage of these endless belt constructions, however, lies in the fact that they stretch very little after being placed in service, so that, in many cases, they will run indefinitely on motor drives without reaching the limit of the motor take-up.

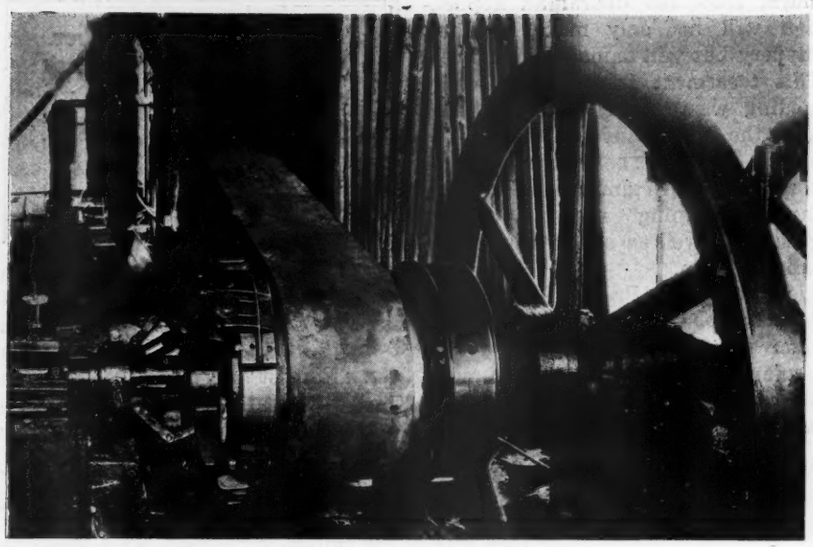
Until such time as more thorough tests are made of the power transmitting capacities of rubber belting, the best guide to their selection is

good judgment, which is based on service performance of particular brands under actual field conditions, plus the reputation of the manufacturer for quality products and progressive developments. This emphasizes the importance of service records.

Buyers of rubber transmission belting in large quantities have found that belts having the same superficial characteristics and selling at the same price may deliver service varying as much as 200 or 300 per cent. The only solution is the establishment of shop records showing the date of installation and the maintenance cost and life of each individual belt, particularly on the more critical drives. This point will be discussed at more length later in the article.

Method of Joining—When it is not practicable to use a factory-built endless rubber belt, the various popular types of metal fasteners serve satisfactorily, provided reasonable care is used in applying them. When plate fasteners are employed, the proper size should be used, as recommended by the manufacturer of the fastener for the particular thickness of belt and size of pulley. The use of oversize fasteners not only prevents smooth operation of the belt, but also strains the anchorage of the hooks and shortens the life of the joint.

All-metal hook fasteners used with rubber belts should be of the type which clinch across the lengthwise strands of the fabric. Leather lacings make an ideal joint for dry conditions, provided they are applied in a workmanlike manner. In punching a belt for lacings the holes should be as small as possible, otherwise the belt is weakened by severing the lengthwise strands.



Oil-well pump drives impose some of the most severe service conditions found in industry.

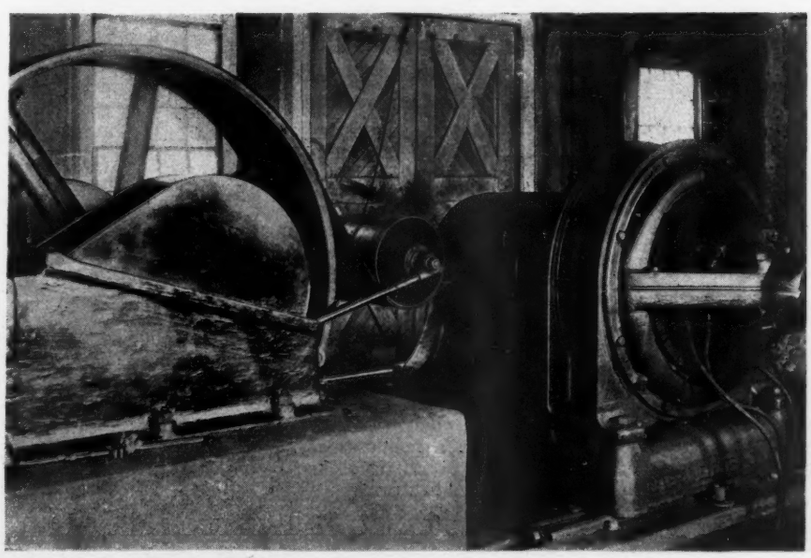
Here a 12-in., 6-ply rubber belt is used on a standard pumping rig in Arkansas. The owner of this oil well property was able to obtain more than 400 per cent increased service by adopting a belt of recently improved design at a 20 per cent higher initial cost per belt.

Initial Tension—A rubber belt should be applied with an initial tension of approximately 15 lb. per in. per ply. This is arrived at roughly by cutting the belt $\frac{1}{8}$ in. per ft. shorter than the tape-line measurement around the pulleys. Inasmuch as the stretch is not exactly uniform in various sizes and makes of rubber belt, this rule is not exact and in some cases an additional shortening will be found necessary. On vertical drives it is advisable to allow $\frac{3}{16}$ in. per ft. in cutting.

Limitations—The principal undesirable operating condition to be guarded against in applying rubber belting is excessive oil. Oils and greases, particularly mineral oils, have a solvent action on rubber which causes it to lose its sealing and adhesive properties in a relatively short time.

Treatments and Cleaning—Rubber belts, when new, sometimes have a white powder on the surface which may be either soapstone or the natural sulphur bloom coming out of the rubber. This usually does no harm, but if the belt, after applying under the proper tension, has a tendency to slip, its operation may be helped by the removal of this powder. This can be done by washing with soap and water or by a light rubbing with a gasoline-soaked cloth or waste. As a rule, however, this powder will disappear after the belt has been in service for a short time. The removal of the powder considerably increases the adhesion between the belt and the pulley.

Because of its permanent flexibility and pliability, rubber belting does not require regular dressing or treatment. If the surface becomes glazed and hard it can be softened by a very light application of vegetable castor oil or boiled linseed oil. Care must be taken not to use too



Here an endless rubber belt operates on a short-center drive in a colliery.

When installing rubber belts for the first time on this type of drive, it is important to specify the exact distance around the pulleys, with the idler down in *normal* position. Indicate to the belt manufacturer that he should make the necessary allowance for stretch. When ordered too short, a rubber belt does not stretch enough to let the idler drop into place and disastrous slipping results.

much, since too liberal an application will not only make the belt slippery but will damage the rubber. This treatment is best applied by holding waste or cloths, moistened with the oil, against the inner face of the belt. If belt dressings are used it is important to avoid dressings containing mineral oil or grease, as well as all dressings containing rosin.

Selecting the Proper Size of Belt for the Job—The first step to consider in selecting a belt for a particular drive is the question of availability. For example, an engineer when designing a drive would do better to use a 6-in., 5-ply belt than a 5-in., 6-ply belt even though it takes a wider pulley, inasmuch as a 6-in., 5-ply belt can be bought in stock almost anywhere, whereas a 5-in., 6-ply belt can seldom be obtained except on a special order from the factory, which naturally involves some inconvenience and delay. Table I lists the standard sizes of rubber belt obtainable in stock from branch houses and dealers.

Table I—Sizes of Rubber Belt Obtainable from Stock

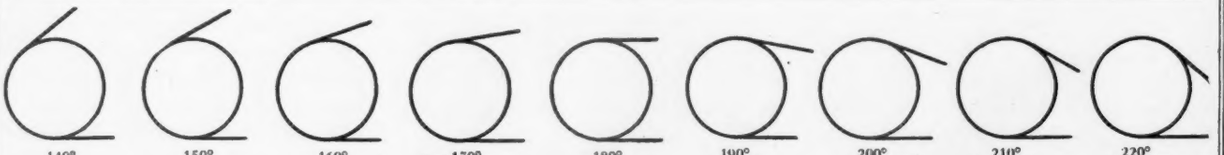
2 in. 3 ply	8 in. 5 ply
2 in. 4 ply	8 in. 6 ply
3 in. 3 ply	10 in. 5 ply
3 in. 4 ply	10 in. 6 ply
4 in. 4 ply	12 in. 5 ply
5 in. 4 ply	12 in. 6 ply
6 in. 4 ply	14 in. 6 ply
6 in. 5 ply	16 in. 6 ply

The question of the relation between the width and thickness of a belt depends largely on the type of drive. A 10-in., 5-ply belt, for example, might be preferable on a drive where pulleys are in alignment and other conditions insure equal distribution of the load across the width of the belt. On the other hand, for imperfect alignment conditions, such as produced by tapered

Table II—Horsepower Rating of Heavy Friction Surface Rubber Belts

(See note at the bottom of the table when selecting belt sizes.)

	Speed in Feet per Minute																	
Size of Belt	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800	3,000	3,400	3,800	4,200	4,600	5,000
2 in., 3 ply	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8.5	9.4	10	10.3	10.6
2 in., 4 ply	1.3	2	2.7	3.3	4	4.7	5.3	6	6.7	7.3	8	8.7	9.3	10	11	12	13	14	15
3 in., 3 ply	1.5	2.3	3	3.8	4.5	5.3	6	6.8	7.5	8.3	9	9.8	10.5	11.3	12.8	14	14.8	15.4	16
3 in., 4 ply	2	3	4	5	6	7	8	9	10	11	12	13	14	15	17	19	20	21	22
4 in., 4 ply	2.7	4	5.3	6.7	8	9.3	11	12	13	15	16	17	18	20	23	25	26	27	28
4 in., 5 ply	3.3	5	6.7	8.3	10	12	13	15	17	18	20	22	23	25	28	32	34	35	36
5 in., 4 ply	3.3	5	6.7	8.3	10	12	13	15	17	18	20	22	23	25	28	32	34	35	36
5 in., 5 ply	4.2	6.2	8.3	11	13	15	17	19	21	23	25	27	29	31	35	39	42	43	44
6 in., 4 ply	4	6	8	10	12	14	16	18	20	22	24	26	28	30	34	38	40	41	42
6 in., 5 ply	5	7.5	10	13	15	18	20	23	25	28	30	33	35	38	43	47	50	52	53
6 in., 6 ply	6	9	12	15	18	21	24	27	30	33	36	39	42	45	51	56	60	62	64
8 in., 4 ply	5.3	8	11	13	16	19	21	24	27	29	32	35	37	40	45	50	53	55	57
8 in., 5 ply	6.7	10	13	17	20	23	27	30	33	37	40	43	47	50	57	62	66	69	71
8 in., 6 ply	8	12	16	20	24	28	32	36	40	44	48	52	56	60	68	75	80	84	86
8 in., 8 ply	11	16	21	27	32	37	43	48	54	59	64	69	75	80	91	100	106	110	113
10 in., 5 ply	8.3	13	17	21	25	29	33	38	42	46	50	54	58	62	71	78	83	87	89
10 in., 6 ply	10	15	20	25	30	35	40	45	50	55	60	65	70	75	85	93	99	103	106
10 in., 8 ply	13	20	27	33	40	47	53	60	67	73	80	87	93	100	113	125	133	138	142
12 in., 5 ply	10	15	20	25	30	35	40	45	50	55	60	65	70	75	85	93	99	103	106
12 in., 6 ply	12	18	24	30	36	42	48	54	60	66	72	78	84	90	102	112	119	123	127
12 in., 7 ply	14	21	28	35	42	49	56	63	70	77	84	91	98	105	119	131	139	144	148
12 in., 8 ply	16	24	32	40	48	56	64	72	80	88	96	104	112	120	136	150	159	165	170
14 in., 6 ply	14	21	28	35	42	49	56	63	70	77	84	91	98	105	119	131	139	144	148
14 in., 8 ply	19	23	37	47	56	65	75	84	93	103	112	121	131	140	159	175	186	194	200
16 in., 6 ply	16	24	32	40	48	56	64	72	80	88	96	104	112	120	136	150	159	165	170
16 in., 8 ply	22	32	43	53	64	75	85	96	107	117	128	139	150	160	181	200	213	222	229
18 in., 6 ply	18	27	36	45	54	63	72	81	90	99	108	117	126	135	153	168	180	186	192
18 in., 8 ply	24	36	48	60	72	84	96	108	120	132	144	156	168	180	204	224	238	246	254
20 in., 6 ply	20	30	40	50	60	70	80	90	100	110	120	130	140	150	170	186	198	206	212
20 in., 8 ply	26	40	54	66	80	94	106	120	134	146	160	174	186	200	226	250	266	276	284
22 in., 6 ply	22	33	44	55	66	77	88	99	110	121	132	143	154	165	187	205	219	226	233
22 in., 8 ply	28	44	59	73	88	103	116	132	147	160	176	191	204	220	248	275	292	303	312
24 in., 8 ply	32	48	64	80	96	112	128	144	160	176	192	208	224	240	272	300	318	330	340



140°	150°	160°	170°	180°	190°	200°	210°	220°
Subtract 17%	Subtract 13%	Subtract 8%	Subtract 4%	Rating of Rule I	Add 4%	Add 8%	Add 11%	Add 15%

NOTE—This table is based on a 180-deg. arc of contact. Where the arc of contact is greater or less, due to unequal pulley diameters, the value as given by the table should be increased or decreased according to the values indicated in the above chart, which gives the percentage correction for each 10 deg. from 140-deg. to 220-deg. arc of contact. The rating at 180 deg. is based on Rule 1 which is that a heavy, friction-surfaced rubber belt will transmit 1 hp. for each ply of fabric 1 in. wide at a speed of 2,400 f.p.m., and at other speeds in proportion. For high speeds deductions are made in this table from this basis of rating according to the rule to obtain the values given in the last two columns. Ratings at higher belt speeds than given in this table may be obtained as follows: For speeds of 5,000 to 5,500 f.p.m. use the ratings in the table for 5,000 f.p.m.; for speeds between 5,500 and 6,000 f.p.m. use the rating for 4,600 f.p.m. The sizes of belts which are set in bold type in the first column are the commercial or stock sizes which are carried in stock by belt houses. Whenever possible a commercial size should be used because the special sizes must be obtained directly from the manufacturer.

cone pulleys or quarter turns, an 8-in., 6-ply belt would operate more satisfactorily.

Strength and Thickness—When determining the size of a rubber belt or substituting it for leather we assume the tensile strength of rubber belts to be equal to leather in corresponding thicknesses. The following table shows a thickness comparison between friction-surface rubber belts and leather belts:

Rubber Belt	Corresponding Leather Belt
4 ply	medium single
5 ply	heavy single or light double
6 ply	medium double
7 ply	heavy double
8 ply	three ply

Horsepower Rating—Table II affords a convenient and simple means by which it is possible for an industrial man to determine quickly the horsepower rating of all sizes of rubber belt commonly used, with a minimum of calculation. A simple rule for mental calculation is the following: A heavy, friction-surface rubber belt will carry 1 hp. for each ply of fabric 1 in. wide at a speed of 2,400 f.p.m. The rating for other speeds is in proportion. The results obtained by this rule should be corrected for high speeds, as follows: At 4,500 f.p.m., deduct 5 per cent from rating; at 5,000 f.p.m., deduct 10 per cent; at 6,000 f.p.m., deduct 25 per cent.

This correction, while only approximate, will be found in practice to provide sufficient allowance for the loss of pulley grip due to centrifugal force. The result should be also corrected for arc of contact, in accordance with the correction factors at the bottom of Table II.

These simple rules, if fixed in the memory, will be found extremely practicable and dependable. Any method of calculation, no matter how elaborate, is at best only an approximation because certain important factors, such as initial tension and coefficient of friction, are seldom known exactly and have to be taken for granted. Those who depend on tables and charts are lost when these are mislaid. The man who carries the rule in his head never has to resort to guesswork and will save

Table III—Minimum Pulley Diameters Recommended for Special Flexible Rubber Belts*

No. of Plies	Belt Speed in Feet per Minute					
	1,000	2,000	3,000	4,000	5,000	6,000
4	4 in.	4 in.	5 in.	6 in.	6 in.	7 in.
5	6 in.	7 in.	8 in.	9 in.	10 in.	11 in.
6	10 in.	11 in.	12 in.	14 in.	15 in.	17 in.
8	17 in.	19 in.	22 in.	24 in.	27 in.	29 in.

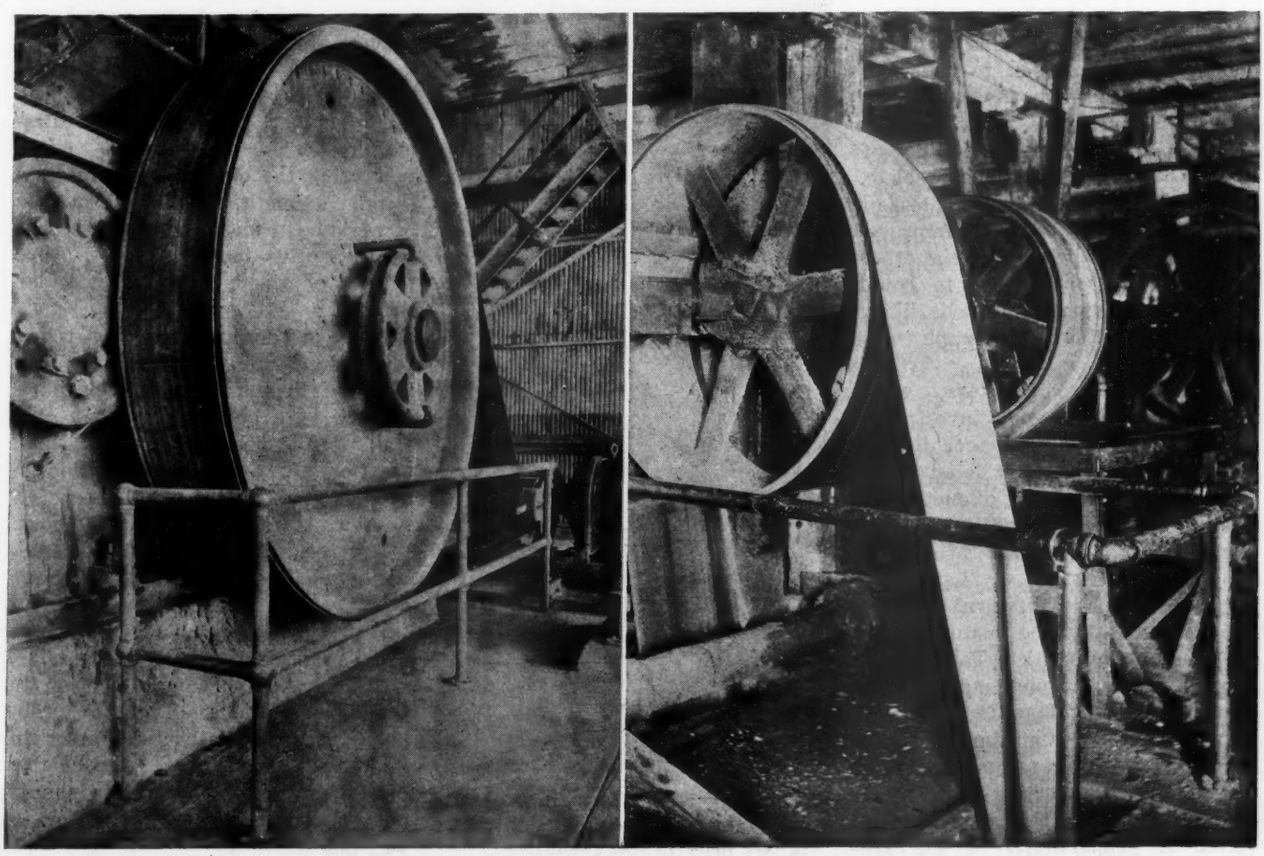
*This table is based on the manufacturer's recommendations for rubber belts of special flexible construction designed for small pulleys. Where belts of regular construction are to be used, these diameters should be increased one-third.

An example of an endless rubber belt operating on a crusher drive in a copper ore concentrating mill.

The motor take-up was adjusted twice in nine months, the total stretch being only 4 in. This is a 20-in., 5-ply heavy endless rubber belt 52 ft. long. The pulley on the 125-hp. motor is 17x21 in. with ¼-in. crown and operates at 860 r.p.m. The driven pulley is 110x21 in. This is operated with a short-center drive at 10-ft. centers.

A typical paper mill drive operating a line of beaters.

This is a 20-in., 6-ply rubber belt 44 ft. 6 in. long. These drives impose severe service on belts on account of the slow speed which is common practice in old mills.



himself much trouble from misapplications.

For example, an industrial operating man who carries the foregoing horsepower rule in mind knows instantly that an 8-in., 5-ply belt is rated at 40 hp. at a speed of 2,400 f.p.m. If it is to be applied on a drive where it will travel at 3,600 f.p.m., he knows its rating would be just 50 per cent greater, or 60 hp. By familiarity with the angles of various arcs of contact, as illustrated in the chart at the bottom of Table II, he can quickly make the proper allowances by deducting or adding an approximate percentage for correction because of the improper working conditions.

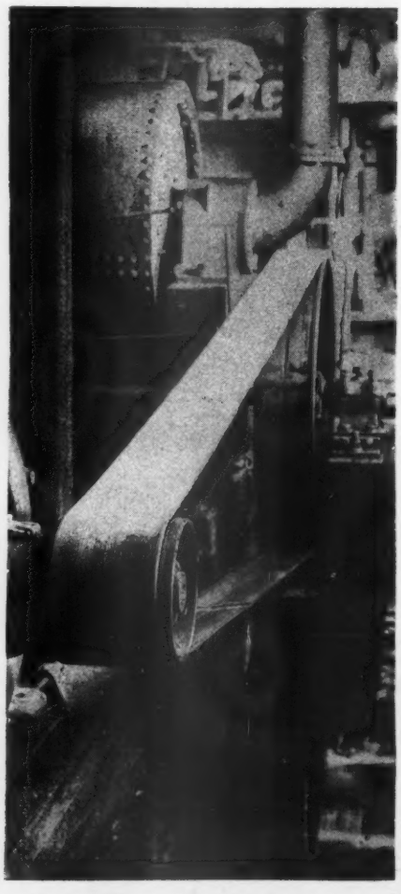
Calculation of Belt Speeds—The calculation of belt speed also lends itself to mental arithmetic by simply multiplying the pulley diameter *in feet* by 3 and then by the r.p.m. of the shaft on which the pulley is mounted. The result is within 5 per cent of the correct speed and is close enough for most purposes when estimating horsepower. When necessary to know the exact belt speed, multiply the pulley diameter in feet by 3.142 instead of 3. If the diameter used is in inches the product must be divided by 12 to get feet.

Minimum Pulley Diameter—The proper relation between the pulley diameter and belt thickness should be kept constantly in mind in deciding on the size of belt to use. An old-time rule, used in the early days of belt manufacture, was to allow 4 in. of pulley diameter per ply of belt. This rule has become obsolete, however, with the increased use of small motor pulleys and the improvement in rubber belts. On the other hand, belt distortion due to rapid bending over small pulleys is likely to cause "bootlegging" or ply separation.

Ample pulley diameters, when practicable, are a good investment, which is reflected in longer life of belts. When possible it is advisable to allow 3 in. of pulley diameter per ply and for speeds above 4,000 f.p.m., 4 in. per ply. When this proportion cannot be maintained, it is advisable to use a high-quality rubber belt recommended by the manufacturer for small-pulley work. Table III is typical of the recommendations of various leading manufacturers of rubber belts on minimum pulley diameters. These recommendations are graduated according to the speed of the belt, as the deteriorating effect is proportional to the frequency of bending as well as to the diameter of the pulley. For this reason a more liberal allowance should be made for drives with abnormally short centers.

Belt Maintenance—As a rule the most important aim in belt maintenance is to avoid shutdowns and production delays due to belt troubles. Prevention of such mishaps can easily pay the cost of assigning to one man the job of watching all drives and taking the responsibility for the condition of all belts. The saving on belt purchases which may be brought about by a good man in such a position, while incidental to the more important aim of promoting steady production, can in itself amount to a considerable figure.

The greatest obstacle against the adoption of such a plan is the difficulty experienced in maintaining such supervision during night shifts. An assistant belt man should then be on the job and responsible to the day man. Such plans have also come to grief, in many cases, through an attempt to do the job too thoroughly and trying to maintain records so elaborate as to be impracticable.



This "hog" refiner drive is a typical example of the adaptability of rubber belts to wet conditions.

It should be sufficient to have each drive numbered and tagged and a record kept showing the following information: (1) Number or name of drive. (2) Department. (3) Exact length belt should be cut. (4) Width. (5) Number of plies. (6) Make of belt. (7) Date purchased. (8) Date applied. (9) Date removed. (10) Date when motor take-up is adjusted, and number of inches motor is moved. (11) Date when belt is replaced, and number of inches taken out. (12) Remarks.

Engineering and Maintenance Department records should be in such shape that a belt man can easily ascertain any desired data on a drive, such as speed of shafts, diameter and width of pulleys, horsepower, and so on, from the records and not have to go out into the plant and shut down a machine to get it. The lack of such records in a plant often necessitates some broad guesswork and is a common cause of belt misapplication.

Belt Failures—One of the inherent advantages of rubber belt is the fact that the nature of the materials and the method of manufacture reduce the possibility of defects to a very small percentage. If examination shows that the friction adhesion is still strong and elastic, the failure can usually be traced to misapplication or bad operating conditions. When a belt fails prematurely, it is a good plan to save it, even though no claim is to be made against the manufacturer, until the belt salesman makes his next round. After inspecting the old belt and studying the drive conditions the salesman is often able to make suggestions that will greatly increase the future service obtained on that particular drive.

The great majority of rubber belt failures are due to fastener trouble. Many of them might be avoided by the use of a belt square when cutting open-end belts. Even a small fraction of an inch of variation in the ends of a belt may throw an uneven strain on one or two hooks, which results in a bad joint.

Storing Rubber Belts—The better qualities of rubber belting as manufactured today are not susceptible to rapid deterioration. It is advisable, however, to give some attention to storage conditions. Light is probably the most destructive factor in its effect on rubber, particularly direct sunlight. Also, belts should not be stored in hot places nor in wet places.

A general view of the interior of the machine shop.

The ample daylight illumination obtained is largely due to the extensive use of continuous sash in the wall area. The main bay in the foreground is 75 ft. by 150 ft. with 35 ft. clear underneath the crane. The lean-to at the right is 40 ft. wide with a clear height of 20 ft. underneath the crane. The stairway to the crane runway is shown in the front corner of the main bay, ending near the letter M. This view indicates in a general way the size of the machine tools, the arrangement of the floor and building, and something of the variety of work handled. The artificial lighting is illustrated more clearly in an accompanying illustration.

Unique features of

LIGHTING SYSTEM for Large Machine Shop

in which unusual service conditions are encountered

By JAMES THOMSON

Chief Engineer, Hubbard Steel Foundry Company, East Chicago, Ind.

THE steel foundry which I am associated with recently erected a large machine shop to do jobbing work on the castings made for our customers. These castings consist largely of iron, steel, and alloy steel rolls for rolling mills, steel gears of large dimensions, and large steel castings for rolling mills, special machinery, locomotives, and cars. Much of this work is of such large size or unusual shape that the customers have no shop facilities capable of handling their castings.

The housing, power servicing, and lighting of the heavy machinery required unusual provisions for effective operation. The machinery installed consisted of two groups: Extra-heavy boring mills, radial drills, planers, and other such machines made up one group; the other group consisted of lathes, milling machines and other ordinary shop tools for the handling of the lighter castings. It was decided to separate these groups because of the different building facilities and operating requirements which would be necessary.

Adequate lighting and ample floor space for storing the large castings near the machine were two of the principal considerations affecting the design of the building. It was finally decided to erect a steel-frame building which consists of a large main bay, 150 ft. by 75 ft. with a clear height of 35 ft. underneath the 30-ton Shaw crane, and a 40-ft. lean-to on the north side extending the full length of the building, with a clear height of 20 ft. beneath the smaller 5-ton Milwaukee crane. The main aisle, however, is capable of accommodating a 50-ton crane. The larger machine tools are placed in the main bay and the smaller ones in the lean-to. The general arrangement is such that the machine tools are located around the outer edge of the bays and the center of the floor is left vacant for temporary storage of castings, before and after machining. How this location of machine tools affects the lighting will be brought out later in the article.

Daytime lighting is provided by the natural light through the large area of continuous steel sash which extends practically all of the way around the building. As the lean-to is on the north side of the building the entire south wall of the main bay and the ends offer an uninterrupted exposure to daylight. Up to this time (the shop was put in operation during August of last year) there has been but little necessity of using artificial light except a few times in the late afternoon and at night.

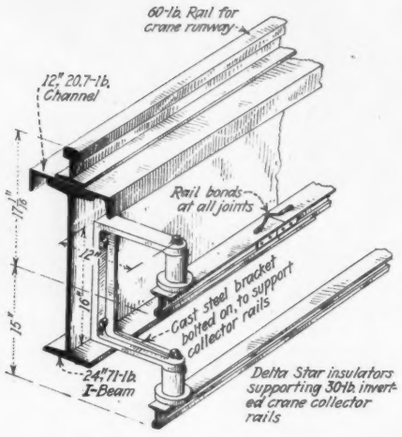
Artificial light is provided by a system of general illumination in which the lighting units are so placed and controlled that when nec-

essary only small sections of the shop, such as around a single machine, need be illuminated. There are no individual lights on any machine. The illumination of the main bay is obtained from a number of 500-watt lamps mounted on the columns at each side of the bay and below the collector rails. Other 750-watt lamps are mounted on the roof trusses and above the craneway. The 500-watt side lamps are installed in Benjamin Electric Company elliptical, porcelain-enameled steel, angle reflectors. The 750-watt lamps are placed in Benjamin deep-bowl, porcelain-enameled steel, railroad-type reflectors.

The side lights are about 30 ft. above the floor level and the special elliptical shape of the reflector directs the light along the side of the bay and around the machine tools, instead of out toward the center of the floor area, which is used for temporary storage. The central area is lighted from the overhead units which also spread their light over the whole width of the bay and so eliminate shadows which would result if only the sidelights were used. Also, the center lights furnish sufficient general illumination for crane service and any other activities that are carried on in other parts of the building away from the machine tools.

The lean-to bay is lighted by 500-watt lamps in Banjamin railroad-type, deep-bowl, porcelain-enameled steel reflectors located on the roof trusses about 22 ft. above the floor level.

All lamps are mounted on Thompson safety lowering switch hangers (Thompson Electric Co., Cleveland, Ohio) to facilitate renewal or cleaning. The chain which supports each lamp unit is enclosed in conduit, which is mounted alongside the column as indicated by *A* in the illustration on this page. The ring in the end of the chain is hooked in a Thompson enclosed fitting Type 65, which may be secured with a padlock through the staple.



This sketch shows the method of mounting the collector rails for the crane.

A cast-steel bracket, which is bolted to the I-beam supporting the crane runway, has two collector rails fastened to it in an inverted position with insulators between. The cast-steel braeket prevents breakage, and no dust can collect on the rails as they are placed upside down.

To service lamps, it is necessary only to snap a rope into the ring on the end of the chain, loosen the disconnecting device and lower the lamp and reflector to the floor. The lamp and reflector units in the roof trusses are serviced in a similar manner by lowering them to the crane bridge. With such facilities all lamps can be cleaned as often as necessary and because of the ease of doing so, they are more likely to be serviced properly. The installation has not yet been operating a sufficient length of time to establish a cleaning and servicing schedule.

Another interesting feature in the control of the lighting units is that each light is operated from an individual switch, instead of in groups, except in the lean-to where two lights are on one switch. The three switches for controlling the lamps in the center of the main bay, the side lamps with elliptical reflectors, and the lamps in the roof truss of the lean-to at the right are indicated at *B* in the illustration on this page. The switches for the elliptical angle reflectors on the other side of the main bay are located on the building columns which support the reflectors. These switches are the V and V series MS, 20-amp., 250-volt rating, manufactured by the VV Fittings Company, Philadelphia, Pa., and are dust- and moisture-tight and fused.

The incoming lighting circuits, one for each row of lamps, are brought in at the end of the building through Type DF, VV Fittings Company, 60-amp. switches.

Connections for air lines with a strainer and blowoff cock are mounted on the columns just below the switches indicated at *B*.

Power for the machine shop and the cranes is obtained at 230 volts, direct current, from two rotary converters. Power is received from the Northern Indiana Gas & Electric Company at 11,000 volts, three phase, 60 cycles and is stepped down to 440 volts for general plant use through three single - phase transformers.

A closer view of one of the machines and lighting arrangement.

Special elliptical, angle reflectors are mounted on each column below the crane runway and controlled from a switch on that column. In addition, lights are placed in the center of the truss above the crane. The lean-to is illuminated by a single row of lamps placed in the center of the roof truss upon the crane way. All lamps are serviced by lowering them with a Thompson disconnecting switch to the floor. The fitting for controlling the lowering of the lamp is shown at *A*. The lighting switches, one for each lamp, are shown on the column at *B*. *C* indicates the location of the crane collector rails which are shown in more detail in the accompanying sketch.

Further reduction to 110 volts for the lighting circuits is made through three 10-kva. General Electric Type H transformers.

All machine tools and the cranes in the machine shops are operated by 230-volt, direct-current motors, most of which are of the variable-speed type. Practically all of the motors came with the machine tools, and so are of various makes and sizes. The motor control, in almost all cases, is of the automatic, push-button type supplied by the Electric Controller & Mfg. Co., Cleveland, Ohio.

Conduit lines to the various machines are set in the concrete floor as it was not desired to bring any overhead obstructions into the craneway. The concrete floor is surfaced with Kreolite wood blocks which are covered and the cracks filled with an asphaltic preparation poured on while hot.

The method of mounting the crane collector rails is somewhat unusual and was designed to prevent the difficulties which result from dust settling on the surface of the rails. This is overcome by mounting the collector rails upside down as shown in the accompanying sketch and at *C* in the illustration on page 18. The 30-lb. collector rails are fastened to the I-beam runways by suspending them from cast-steel brackets by means of Delta-Star type 10340 insulators. We made a pattern and cast the brackets of steel in our foundry. I believe that even if it were necessary to have these brackets made outside, as would be the case where industrial plants do not have a steel foundry, it would pay to have them made of cast steel instead of cast iron as the difference in cost would be more than overcome by the security from breaking. This mounting, I believe, will prevent breakage and eliminate dust trouble, which are two of the more common troubles in connection with crane operation. The 30-lb. collector rails are joined electrically by rail bonds welded on in order to insure a good connection at all times.

As an extra precaution for safety, stairways are used instead of ladders to the crane runway. One of these stairways may be seen at the front of the building in the illustration at the beginning of this article.

Factors That Influence Origin and Extent of Dust Explosions

PLANT construction is related closely to the origin and extent of dust explosions, as will be noted from extracts of a paper by David J. Price, engineer in charge of development work, Bureau of Chemistry, read at Technical Sessions, Chemical Equipment and Process Engineering Exposition, Cleveland, Ohio. In a number of explosions, the value of certain types of construction, for example large window glass areas, has been well demonstrated. In a chemical plant, for instance, the dust-explosion hazard exists in practically all types of processes, such as transporting, energizing, reacting, separating and conditioning. In the transporting process, explosions may originate in the elevators, conveyors, loading and unloading machines, and in practically all types of material handling and conveying equipment.

Fires and explosions have occurred in driers when the temperature has been considerably below the ignition temperature of the material. The question is, What causes these fires? Does prolonged heating at comparatively low temperatures change the chemical composition of grain dust, wood dust, and starch so that the resulting material has an ignition temperature lower than that of the original dust? Some work is being done on this problem by the Bureau of Chemistry at the present time, but no definite conclusions have as yet been reached.

Certain factors contribute to the explosibility of a dust, one of the principal factors being the degree of fineness. Flame propagates rapidly through a 200-mesh cloud, and the rate of flame propagation appears to increase in proportion to the relative degree of fineness. Based on the results of recent work by Bouton and Hayner, it appears, however, that there is a limit to this relationship of fineness to flammability. Recent experiments with two types of coal, one from the Pittsburgh bed in Pennsylvania and the other from the Pocahontas bed in West Virginia, were conducted to obtain a quantitative relationship between fineness of dust and its tendency to flare up when suspended as a cloud and ignited at some point. In reporting this work the investigators state: "The experiments gave the unexpected result that flammability does not increase indefinitely with fineness but seems to reach a maximum and then fall off, or at least remains constant, as the fineness is still further increased."

The design of dust collecting systems is vitally important in this dust explosion problem. In some instances explosions have occurred in the dust collecting pipes and also in the dust collector. The successful collection of dust by mechanical equipment (in the handling by fans and pipes) bears a close relation to the explosive concentration limits. In the design of these dust collecting systems it is essential that engineers be fully acquainted with the dust explosion hazard and the conditions under which the dusts can be ignited and flame propagated.

At present the relation of relative humidity to explosion frequency is receiving much attention. It has been claimed that the explosion hazard will be reduced by an increase in the relative humidity. So far the work done on this phase of the problem has been limited. It appears, however, that it cannot be generally claimed that an increase in relative humidity will entirely eliminate the dust explosion hazard.

It is true that with increased humidity the possibility of formation of static electricity may be reduced, owing to the thin film of moisture which acts as a conductor for the static electricity, thus permitting the charges to be neutralized or grounded. There are engineers who feel that much protection can be afforded by the introduction of a humidity control system and that the entire subject is a matter for further research.

Dust explosions occur in what may be termed two stages: primary and secondary. A primary explosion is usually an ignition of a small quantity of dust with localized effect. The concussion accompanying this original ignition, however, is sufficient to shake into the air any settled or collected dust, resulting in a rapid propagation of flame and in what is termed a secondary explosion. In this explosion a considerable pressured is developed and as a rule the plant is badly damaged.

The need of effective dust-removal systems for both suspended and

static dust is, therefore, shown. By efficient dust removal the propagation of flame is prevented and the secondary explosion, as a rule, limited in extent. Progress has been made recently in the development of pneumatic cleaning systems for the removal of settled dust throughout the plant. It has been demonstrated that proper maintenance and "good housekeeping" are essential in dust explosion control.

Method of Conveying Steel Chips by High Air Velocity

THE hand sorting of finished automatic screw machine work from its waste, the chip, is about the least desirable job in modern industry. In our plant between 500 and 600 tons of steel shavings are run each year from our automatic screw machine room.

The shavings, work, and what oil comes from it, are raked into low pans on truck wheels. The material is then shoveled into the centrifugal extractor pans where the oil is whirled out and recovered. Formerly, the extractor pan was dumped into screen-bottom hand shakers on casters running on an angle-iron track. After the fine chips had fallen through the screen into the dump box truck, the large chips were picked out, and then the work was picked out and placed in "tote" boxes. When the dump box was full, it was run up one flight on the elevator and out on a runway over the chip pile, and dumped. This job of sorting and extracting kept four men busy, and the labor turnover was an ever-present problem.

Our company bought a McKenzie separator, and this, of course, did its own sorting, but the bulk of the chips and shavings was delivered about 2 ft. from the floor highly inflated, which condition was due to the air blast of the separator. Therefore, although we did not have to sort the finished work from the chips, we did have the extra operation of shoveling the chips from the floor into a dump box truck. So we set out to devise some method which would automatically handle the chips, in place of shoveling them.

In our unused, obsolete machine building (aptly named the Morgue) we had a No. 5 B. F. Sturtevant forge blower which would give us a good, high-pressure air blast; so it was decided to use this blower in a small experimental model that was built to remove chips. As the model worked satisfactorily, we then went ahead and built and installed a machine to remove the chips.

As the McKenzie separator is rather high for easy loading, it was lowered into the floor, bringing the loading tray down to the 3-ft. level, or about on a level with the top of the extractor. The room is on the ground floor and there is no basement; so it was necessary to bury the conveyor pipe under the cement floor from the conveyor to the outside wall of the building. Where the conveyor pipe is buried under the cement floor, it is surrounded by a 10-in. tile pipe which is cemented into the floor. The conveyor pipe inside the tile pipe is made of No. 16 9-in. galvanized iron removable liners so that this part of the conveyor pipe can be easily removed from time to time as it wears and needs to be replaced.

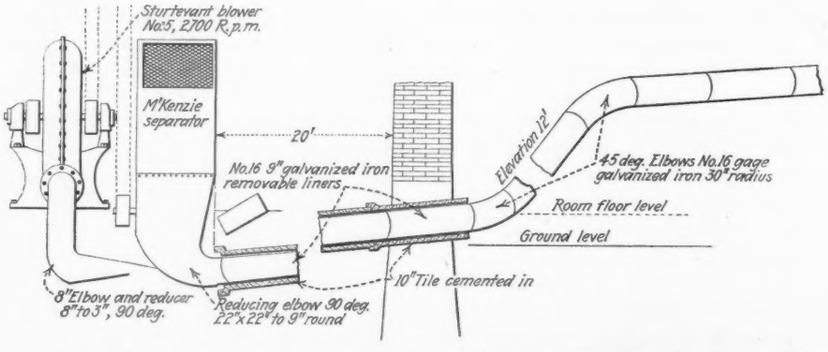
In order to collect the chips as they are discharged from the separator a reducing 90-deg. elbow was made, it being 22 in. square at the top and where it connects to the separator and 9 in. in diameter at the bottom end where the chips are directed into the conveyor pipe. The Sturtevant blower was next lined up parallel to the separator, the blower being driven at 1,800 r.p.m. by the same counter-shaft that drives the separator. The discharge pipe of the blower was connected to the large, reducing elbow on the separator by a 90-deg. round elbow, reducing from 8 in. to 3 in. The blower elbow connects with the larger one at a point close to the end of the tile which surrounds the conveyor pipe, as shown in the accompanying illustration. The discharge end of the conveyor pipe was elevated about 12 ft. above the floor level.

As the boxes and arbor were not in good condition, they would not stand the speed necessary to produce the strong blast needed. Therefore, it was decided to do what we have found to be an economical practice in the long run; that is, to install ball bearings. A set of Fafnir bearings was installed on this job, and the speed raised to 2,700 r.p.m. All ran well for two months when it was discovered that the tile had been cut so badly as to cause the system to plug up. The original iron pipe installed was of No. 22 gage, and it was also badly cut, particularly at the elbows. The weight of metal was increased to No. 16 gage, and the tile was lined with one soldered length of No. 16 gage, 9-in. galvanized iron pipe which was soldered in order to facilitate removal if necessary.

The system has now been running for two years, and has reduced the labor cost in that room 50 per cent, for two men now do what was formerly accomplished by four men. Maintenance costs are low, and the labor turnover problem has been eliminated. What was once a very undesirable job, is now a good one.

Combined separator and chip conveyor.

The conveyor pipe rises to an elevation of 12 ft. and the chips are piled to a height of 20 ft. The 10-hp. motor which drives the blower and the separator is sufficiently large to force the chips a total distance of 125 ft.


Sturtevant blower No.5, 2700 R.p.m.
M'Kenzie Separator
20'
No.16 9" galvanized iron removable liners
Elevation 12'
45 deg. Elbows No.16 gage galvanized iron 30" radius
Room floor level
Ground level
10" Tile cemented in
8" Elbow and reducer 8" to 3", 90 deg.
Reducing elbow 90 deg. 22"x22" to 9" round

A point to remember in connection with a discharge pipe of this sort is to make the turns in the pipe as long as possible, it being generally advisable to use a 30-in. radius on a 9-in. line, for long bends have a tendency to reduce the wear at the elbows. If different conditions are encountered on a new job, it will only be necessary to make a few minor changes in the construction as shown here, for the principle of design would remain the same.

Plant Engineer, R. J. COLLINS.
Millers Falls Co.,
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Mush Coils for A.C. and D.C. Motor Windings

together with complete data in tabular form that give details of these coils in the types used in different designs of motor windings

By A. C. ROE
and
D. H. BRAYMER
Consulting editor, Industrial Engineer

THE PRECEDING article of this series, which appeared in the December issue, dealt with the general applications of mush or hit-and-miss coils and gave some pointers on winding rules for the different types. In this article more details are given on the construction, shaping and insulation of these coils for direct- and alternating-current windings. The tables give the essential features of the coils discussed and refer to the photographs, which show particular features of construction.

THE types of mush coils that were discussed in the December, 1926, issue, and will be further dealt with in this article, can be divided into three general types, as follows:

(1) Flat mush (*M.*)
(2) Mush pulled coils (*M-P.*)
(3) Involute mush (*I-M.*)

The letters in parentheses indicate the symbols used with each type of coil in what follows.

Each of the above types of mush coils can be divided into other types. For example, in the "flat mush," we have the basket winding coil, two-layer diamond coil, and the rectangular-shaped coil for bipolar, d.c. armatures using the staggered or in-and-out winding. These are also arranged according to the shape and methods of bringing out the leads and ways of taping. The details of construction will be shown in photographs with insulation specifications furnished for each type.

In the "mush pulled" coil we have stator and rotor coils with different methods of bringing out the leads and taping.

In the "involute" class also, the leads and taping are the distinguishing features.

With each type of coil shown in the photographs a symbol is used such as M-1, M-2, etc. The accompanying tables list these different types and the methods of winding, insulating, etc. These tables with symbols and photographs will constitute a master manufacturing and insulating information chart that will enable the coil man to call for any mush type of coil by symbol number and have it wound and insulated as desired. This will reduce the writing up of coil orders to a minimum.

Flat Mush Coils Used in D.C. Windings.—Fig. 1 shows a flat mush coil (M-6) with the leads brought out from the end of each slot section. This type is used principally on direct-current armatures and the leads per coil side are divided up into as many groups of conductors as the number of bars divided by the total number of slots. The number of wires per sleeve is equal to one-half the total number of active wires per commutator bar. The term *active wires per bar* is used to account for dummies. That is, suppose we have a commutator and on inspecting the front of the neck of any one bar we find eight wires. On checking the rear of this bar we find four wires leading from the neck to the winding. We then know that this commutator has four active wires per bar and four dummy wires per bar, and since the leads of any direct-current armature are arranged in two layers (top and bottom leads) we know that each top and bottom lead will have two wires per sleeve, or that the conductor of each single coil consists of two strands.

The number of different colored sleevings to use depends upon the number of single coils per winding unit, and in every case where there is more than one single coil wound into a unit, different colors should be used while winding the coils. Care must be taken to make sure that the same color is put on the start and finishing leads of each individual single coil. This is done by putting on an even number of sleevings (as 2, 4, or 6 at one time) over the wire making up the single coil. The use of colored sleeving while winding the coils saves the armature winder the trouble of lighting out and pairing up the leads.

The sleeving should be fastened with glue at a point approximately ⅛ in. into the slot section. This prevents the sleeving from slipping up and making a ragged looking job.

Fig. 2 shows a flat mush coil (M-7) that is taped all around. This coil is used for open-slot machines.

Fig. 3 shows a flat mush coil (M-8) that has only the ends taped; that is, the parts not embedded in the slots. The sleevings and leads are fastened with this tape. This type of coil is used in partly-closed-slot machines, or where the slots are deep and narrow. In case the untaped sections were easy to fan out, if the sides are taped, the wires would tend to bunch up, making a semi-round or square coil section which would necessitate the winder flattening the coil sides with pliers, which is likely to cause short-circuits.

Table I and Figs. 1, 2 and 3 cover flat mush coils of the two-layer diamond shape as used in direct-current armatures.

The coil shown in Fig. 2, type M-7, should be used whenever possible, as it can be finished complete when wound. The type M-6, Fig. 1, requires the armature winder to tape the end after the sides are threaded into the armature slots. Type M-8 requires care both in the taping and also in placing the coils in the armature.

Flat Mush Coils Used in A.C. Stators.—We will next consider the flat diamond, mush-shaped coil as used in two layer a.c. windings. This

Table I—Flat Mush Coils for Direct-Current Armatures
(See Figs. 1 to 3)

Symbol	Fig. No.	Model	Coil Making Directions	Operations
M-6	1	Untaped	Wind mush. Tie with two or four cords. Bring leads out at ends of slot section. Use colored sleeving.	Make mold, wind and sleeve.
M-7	2	Taped	Same as M-6 except apply one layer of 0.0045-in. cotton tape half overlapped all around. Apply tape tight.	Make mold, wind, sleeve and tape.
M-8	3	Ends Taped	Same as M-6 except ends only are taped using 0.0045-in. cotton tape extending ½ in. on slot section and catching sleeving under tape. Apply tape tight.	Make mold, wind, sleeve and tape.

type of coil is cheaper to make than a mush pulled coil, for when it is wound it is ready for the armature winder, whereas the pulled coil requires the making of puller blocks and calls for extra handling and additional labor for pulling the coils to shape. But, on the other hand, if the flat diamond mush coil contains a large number of turns of a large size wire, it becomes hard for the armature winder to shape the coils and there is considerable danger of short-circuits. As a rule, any coil using wire larger than No. 15 and having a cross-section greater than ½ in. square should be made mush puller. There will be exceptions to this rule of course, but this will eliminate the stiff coils or hard-shaping ones.

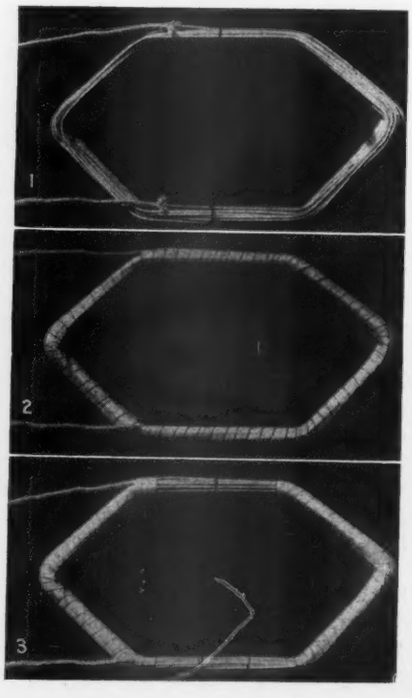
Fig. 4 shows the plain flat diamond mush (M-1) coil. This coil is wound with single-cotton-covered and enameled wire; both leads are taped or sleeved while winding and the coil is tied in four places with the leads left loose, that is, not tied to the coil. This is the simplest coil to make, but the loose leads give the armature winder trouble and a high priced man is slowed up.

The next coil type, Fig. 5, is the basket coil (M-2). This is used in the basket type of one-coil-per-slot winding. The leads of this coil are sleeved and the coil is fastened on the ends only with two turns of ¾-in. friction tape. Note that the leads are brought out on the long cell side or bottom of the coil. The long cell in this type is the bottom cell, as it has to be bent down against the stator rim to allow the top sections to pass.

The M-3 coil, Fig. 6, is the same as the M-1 flat diamond mush, except that the leads are tied to the body of the coil with a band of double-strand, fine linen thread about $\frac{1}{16}$ in. in diameter. Two turns are taken around each lead and one or two turns around the diamond loop. This takes very little time and results in a better coil; also, it saves the winder time in winding and connecting the stator.

The M-4 coil, Fig. 7, has the front diamond point taped with one layer of .007-in. x ¾-in. cotton tape half-lapped and the leads tied after taping. This is a good construction to use for machines that operate on 440 or 550 volts in dirty places, when the coil ends are not taped after they are in place in the stator.

The M-5 coil, which is the same as the one shown in Fig. 18, is a flat mush coil with the ends partly taped. The tape is started on the bottom slot section of the coil and extended along the slot portion a distance that will bring the end of the tape ⅛ to ⅜ in. under the winding cell on both ends. The bottom end and diamond points are taped and the taping is stopped at a distance two-thirds of the total length of the top coil ends. With this type of coil, the winder does very little taping, the section left uninsulated being the only part taped by the winder.



Construction of flat mush coils for direct-current armatures — See Table I.

Fig. 1—Flat mush coil (M-6) with the leads brought out from the end of each slot section. Fig. 2—Flat mush coil (M-7) taped all around for open-slot machines. Fig. 3—Flat mush coil (M-8) with the ends taped, showing method of fastening down the sleeving and leads.

Flat Mush Coils for Bipolar D.C. Armatures.—We will next consider the flat mush coils for two-pole, direct-current armatures. These are commonly called bipolar motors, and this is the reason for using the symbol "Bip." The armatures for these motors generally use the staggered or in-and-out type of winding.

Fig. 9 shows the Bip-1 coil, which has both the leads brought out on the end near the top slot section. This coil is of the long-pitch type with one slot section longer than the other, the long side being the top half. The leads should be brought out approximately ½ in. from the top cell and spaced approximately ¼ in. apart.

Fig. 10 shows the Bip-2 coil, which is used on armatures that have deep and narrow slots. In most cases it is easier to wind the armature if the slot portion of the coils is left untaped. The ends only are taped with sufficient insulation placed in the slot. When possible the tape should extend around the corners and onto the slot section at the leads ¼ in., but in some cases it will be found necessary to stop the tape on the ends on a line with the inside edge of the slot section of the coil.

Fig. 11 shows the Bip-3 coil, which is taped all around. The leads should be well fastened with two turns of tape and the ends of the sleeving glued and caught under the tape.

Fig. 12 shows the Bip-4 coil. This is similar to the Bip-1, except that it has a narrow pitch and half-round ends. This shape of coil is more expensive than the Bip-1 as it requires more work in making the mold and also requires more labor on the part of the armature winder to shape each coil.

Fig. 13 shows the Bip-5 coil. This is the same as the Bip-4 with tape applied all around and the leads brought out at the slot section. The coil shown is for a low-voltage armature and the leads are not sleeved, as the lead space is usually limited.

Fig. 14 shows a special coil, the Bip-6. This is similar to the Bip-3 except that the leads are brought

out at the end of each slot section. While this coil is shown with the bipolar coils and is of the same shape, it is used principally on small, four-pole, wave-wound armatures.

Mush Pulled Coils for A.C. Machines (See Table IV).—As already mentioned, these coils are more expensive than the flat mush coils. The size of wire, number of turns and total cross-section of the coil and the slot proportions are the deciding factors in determining whether to make the coils flat or pulled. The winder's time to shape the flat coil and also the amount of pounding or shaping necessary should be given careful thought as two or three hours saved in making the coils may mean four to six hours lost in winding. Deep, narrow slots require a mush pulled coil.

Fig. 15 shows the plain mush pulled coil, M-P-1. Both leads are taped or sleeved while winding, all wires in hand being placed in the same sleeve or tape. The coil is tied in four places with a strong cord. The coils are next pulled to shape by hand or in a pulling or spreading machine and the leads bent as shown, but not tied. This makes the cheapest mush puller coil, and it is satisfactory when the coil ends have to be taped by the winder.

Fig. 16 shows the M-P-2 coil. This is similar to the M-P-1 except that when pulling it, the leads and the front diamond are tied with a few turns of light linen or flax. This coil is used when the ends are not taped, as the tying secures the leads and strengthens the front end of the coil.

Fig. 17 shows the M-P-3 coil. This is similar to the M-P-1 except that the diamond points are taped and the leads tied with two or three turns of strong cord. This coil has the diamond points well protected and is used in the stator without any additional insulation on the ends except reinforcement for the phase coils. When wound stators are allowed to stand around as spares without end bells or rotors, or in some dirty place, the M-P-3 is the best coil to use.

Fig 18 shows the M-P-4 coil with the ends taped. This is the same as the M-5 (Table II) except that the M-P-4 is pulled. When taping the M-5 or M-P-4 coil, care should be taken to start the tape on the bottom or short cell for both rotor and stator coils.

Details of how to wind a small stator using the M and M-P coils are given in Chapter 21 of "Rewinding Small Motors" by Braymer and Roe, published by the McGraw-Hill Book Company.

Much Pulled Coils for D.C. Armature (See Table V).—Fig. 19 shows the M-P-5 coil, which is the same as the M-6. Fig. 20 shows the M-P-6 coil, which corresponds to the M-7 in Fig. 2, and the M-P-7 coil in Fig. 21 compares with the M-8 with the exception that the M-P coils are pulled to shape.

Coils *A* and *B* in Fig. 22 show a pulled type of coil used on bipolar armatures. This coil is first wound on a shuttle to the shape shown in Fig. 22*A*. The coils are then taped and dipped in a plastic varnish. The coil is pulled to shape as follows: One side of the coil is placed in a block that is cut the length of the straight part required for the bottom slot section of the coil. An equal amount of the coil projects on each side of this block, as shown in Fig. 23*A*. The cell block is fixed by holding it in a vise. Next, both ends are pulled straight down until the top half of the coil is approximately ¼ in. above the bottom cell block. This is shown in Fig. 23*B*. Next, a cell block is put around the top half of the coil and this part pulled out to the proper pitch. The coil then takes the shape shown in Fig. 22*B*.

This type of coil is expensive to make in lots of one set, as a special shuttle having large pins is required. This can be made from a piece of fiber cut to the shape of the coil in Fig. 22*A*. Also, an extra shaping operation is required as shown in Figs. 23*A* and *B*. The reason for this is that the coils are wound with a large size of wire in layers. The coil in Fig. 23 has approximately four turns of two No. 11 d.c.c. wires, which would be hard for the winder to shape if flat wound. This coil could be changed to the flat Bip-3 type shown in Fig. 11 by using four wires in hand of a smaller size of single-cotton and enameled wire

Table II—Flat Mush Coils for Alternating-Current Stators

(See Figs. 4 to 8)

Symbol	Fig. No.	Model	Coil Making Directions	Operations
M-1	4	Plain	Wind and tape or sleeve both leads. Tie with four cords.	Make mold and wind.
M-2	5	Basket	Wind, sleeve leads and tie with friction tape.	Make mold and wind.
M-3	6	Tied	Same as M-1 except leads are tied with two strands of linen thread.	Make mold, wind and tie.
M-4	7	Taped and tied	Same as M-1 except front diamond point is taped ¾-in. each side with 0.007-in. tape and leads tied with two or three turns of cord.	Make mold, wind, tape and tie.
M-5	8 Same as Fig. 18	Ends taped	Same as M-1 except ends are taped with 0.0045-in. tape half lapped. Use ¾-in. on the bottom cell section ending ¾ the length of the diamond end on top part of coil.	Make mold, wind and tape.

Construction of flat mush coils for alternating-current windings—See Table II.

Fig. 4—Plain, flat diamond mush coil (M-1) showing method of tying in four places, with leads left loose. Fig. 5—Basket coil for one-coil-per-slot winding. Note how the coil is tied at the ends and the leads twisted to hold them in place. Fig. 6—This coil (M-3) is the same as M-1 except that the leads are tied to the body of the coil, which saves time for the winder. Fig. 7—Mush coil (M-4) with front diamond point taped for use in machines in which the coil ends are not taped after being placed in the stator. Coil M-5 is the same as the one shown in Fig. 18 except that it is not pulled.

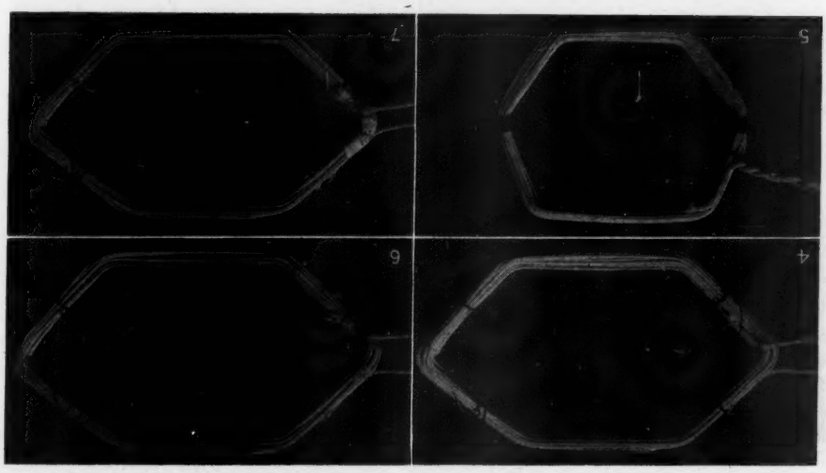


Table III—Mush Coils for Bipolar Direct-Current Machines
(See Figs. 9 to 14)

Symbol	Fig. No.	Model	Coil Making Directions	Operations
Bip-1	9	Untaped	Wind using colored sleeving. Bring out leads on ends at top cell.	Make mold and wind.
Bip-2	10	Ends taped	Same as Bip-1 except tape ends with 0.004-in. cotton tape tight. Catch leads and sleeving, first lead ½ in. from top cell. Leave ½ in. between start and finish leads. Tape to extend ½ in. into slot sections.	Make mold, wind and tape.
Bip-3	11	All taped	Same as Bip-2 except slot sections are taped.	Make mold, wind and tape.
Bip-4	12	Untaped	Same as Bip-1 except narrow pitch and round ends with leads at end of each slot section.	Make mold and wind.
Bip-5	13	All taped	Same as Bip-4 except tape with 0.004-in. cotton tape tight. Catch leads and sleeving under tape and bring out leads at end of slot sections.	Make mold, wind and tape.
Bip-6	14	Taped	Same as Bip-3 except one long and one short cell lead at end of slot sections. Coil wide pitch.	Make mold, wind and tape.

and would make a more pliable coil and a cheaper coil that will not waste the winder's time. Also note that the leads in Fig. 22 are brought out at the center of the coil. This could be changed to the method shown in Fig. 11, as the leads would be out of the way while winding, but there might be a few cases where the front end room would be scant. In that case the leads would have to be brought out as in Fig. 22.

Winding Groups of Coils Without Cutting the Wire.—The present trend is toward winding mush coils for a.c. machines on a gang mold, or winding a complete pole-phase group before cutting the wire. This eliminates a number of soldered connections and also reduces the connecting time, since fewer stubs have to be taped and there are fewer leads to skin.

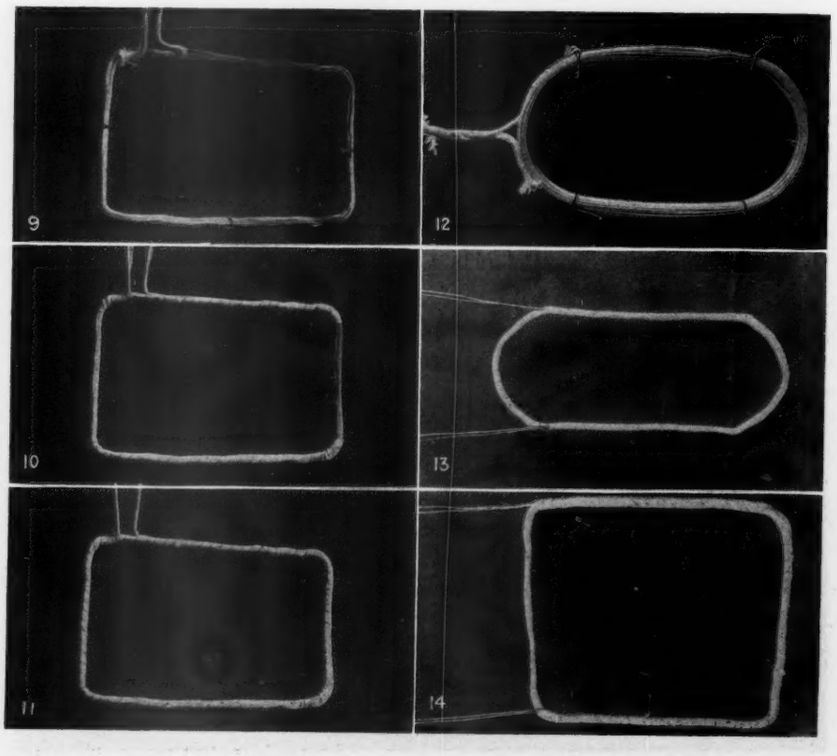
The shape of the coil does not hinder its being made on a gang mold since flat diamond mush, mush puller and concentric chain coils are being made in this manner.

Fig. 24 shows a pole-phase group of coils wound on a gang mold for a large, single-phase stator. There are six coils in this group all of different sizes, the outside or largest coil having fewer turns as the groups overlap in the stator. Notice how the wire is carried from the inside coil to the next size adjacent coil, or the finish of the first or inside coil is carried up and to the left to start the second coil. In the group shown five soldered joints have been eliminated. These coils are wound with four wires in parallel, using single-cotton and enameled wire. The gang mold eliminates the skinning and cleaning of 40 wires for each pole-phase group, which is quite an item as enameled wire is hard to scrape clean for good soldering. Note that the starting and finishing leads of the group are left long enough so that they can be used for jumpers to connect the pole-phase groups together.

The concentric type of winding having more than one size of coil per group is the ideal one for gang mold windings, regardless of whether one set of coils or more is to be wound. A number of different sized center blocks must be made in any case; therefore, it will cost very little more to make the spacing washers used between coils on the gang mold.

In the case of flat diamond mush coils, there is very little to be gained by using the gang mold idea for one set of coils unless it happens to be for a popular type and size of motor that might repeat on different repair orders. However, if the repair shop is located in an industrial plant, it might be a good investment to make a good gang mold, give it a number and include it in the motor record card for future use.

The gang mold is also used for mush pulled coils, the shuttle being arranged for winding a full pole-phase group. There is a limit to the number of coils that can be made as a unit of the mush puller type. This depends on the number of turns in each coil, the size and number of wires in hand and the number of coils per group. The restriction in this case is in the pulling, not in the winding, for in the pulling operation, a



Mush coils for bipolar, direct-current armatures—See Table III.

Fig. 9—Mush coil (Bip-1) with leads brought out on the end near the top slot section. This is a long-pitch coil with one slot side longer than the other. Fig. 10—This coil (Bip-2) is used on armatures that have deep narrow slots. The slot sides are not taped, but the ends are. Fig. 11—This coil (Bip-3) is taped all around and the leads are well fastened with tape. Fig. 12—Mush coil (Bip-4) similar to Bip-1 except for the narrow pitch and half round ends. Fig. 13—This coil (Bip-5) is similar to Bip-4 except that it is taped all around and the leads are brought out at the slot section. This coil is for low-voltage armatures. Fig. 14—This is a special coil (Bip-6) similar to Bip-3 except that the leads are brought out at the end of the slot sections. This coil is used mostly for four-pole, wave-wound armatures.

Table V—Mush Puller Coils for Direct-Current Armatures

(See Figs. 19 to 21)

Symbol	Fig. No.	Model	Coil Making Directions	Operations
M-P-5	19	Plain	Wind on shuttle using single cotton covered and enamel wire. Sleeve while winding using colored sleeving. Tie in four places. Pull and bring out leads at end of slot sections.	Make shuttle and blocks, wind and pull.
M-P-6	20	Taped	Same as M-P-5 except taped all around with 0.007-in. or 0.004-in. cotton tape, semi-tight. Catch leads.	Make shuttle and blocks, wind, pull and tape.
M-P-7	21	Ends Taped	Same as M-P-5 except ends only are taped. Catch leads and extend tape ¼ in. into slot sections.	Make shuttle and blocks, wind, pull and tape.

large mass of wire is hard to handle; that is to hold and pull out and still hold in shape.

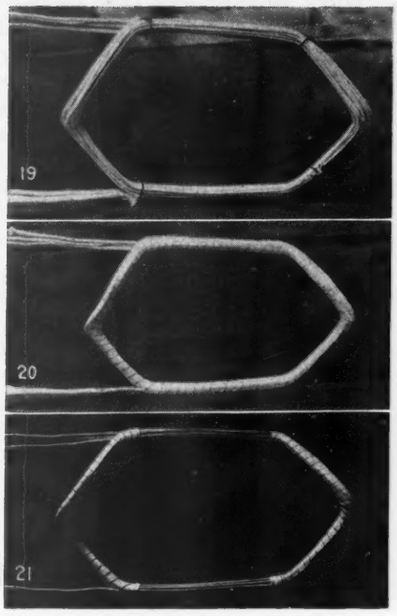
Winding of Mush Coils.—With the flat mush type of coil for d c. armatures (Fig. 1) the coil should be started on the short cell or bottom cell side. This will allow the armature winder to put his leads on the bottom and make a better job. The finishing lead can be arranged to be on top, as in Fig. 1, which shows the starting lead brought out in this manner, and Figs. 2 and 3, which show the finished coil.

With the flat mush coils, enough tension should be used while winding the coils to make them firm, and on medium-sized coils, four cords will be sufficient to hold the coil. When placed as in Fig. 4 they are out of the armature winder's way and the two top cords can be pushed up towards the front diamond point, helping to hold the leads, and can be left on if the coil ends are not taped. The two rear cords can be cut off by the winder after the coil is in place.

With the Bip type of coil four cords are also used, spaced 90 deg. apart, at the center of both slot sections and at the center of both ends, as shown in Fig. 9.

The basket type of coil, Fig. 5, requires only two pieces of friction tape placed as shown. The leads should be sleeved or taped while winding. Sleeving is the quickest to use and for all a.c. mush coils a quantity of No. 3 white (.08-in. inside diameter) sleeving can be cut 4 in. long and used for almost all jobs.

Note the manner of placing the sleeving, as shown in the photographs of the various types of coils. As a general rule the sleeving on a.c. coils should extend at least 1 in. inside the coil, and for d.c. coils ⅛ in. to ¼ in. into the slot sections, except in the Bip type. The method of placing the sleeving on this type is shown in Fig. 9.



Mush pulled coils for d.c. armatures—See Table V.

Fig. 19—This coil (M-P-5) is the same as M-6 in Fig. 1, except that it is pulled and tied differently. Fig. 20—This coil M-P-6 corresponds with coil M-7 in Fig. 2 and is used in open-slot armatures. Coil M-P-7, Fig. 21, corresponds with coil M-8 of Fig. 3.

In Fig. 5 note the manner in which the sleeving is extended past the corner into the long cell section approximately ½ in., and also past the top point. Above all, keep all types of mush coils free from crosses in the slot section and feed the wire from one side of the mold to the other slowly and smoothly, particularly on coils that have to be threaded into the slots, since all crosses must be worked out of the slot sections by the armature winder as he threads the wires in. This not only slows him up but, what is worse, it concentrates the crosses at one point at the end of the slot and if any pounding is required to shape the coil, there is danger of shorts.

Mush puller coils for a.c. stators—See Table IV.

Fig. 15—Plain mush pulled coil (M-P-1) on which the leads are taped or sleeved while winding. Fig. 16—This coil (M-P-2) is similar to M-P-1 except that the leads and front diamond are tied while the coil is being pulled. Fig. 17—This coil (M-P-3) is the same as M-P-1 except that the diamond points are taped and the leads tied. Fig. 18—Coil M-P-4 shown here is the same as coil M-5 in Table II, except that it is pulled.

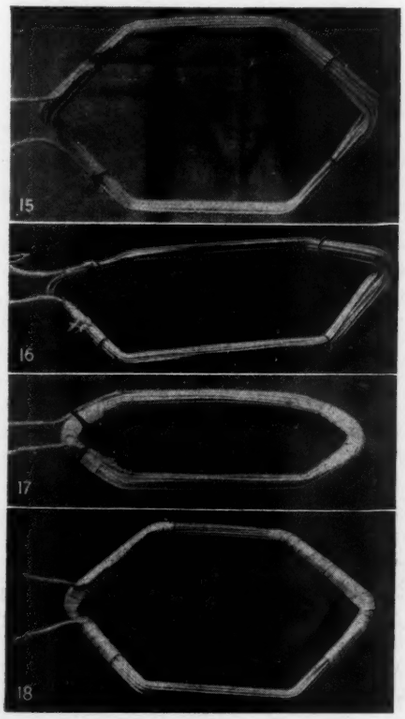


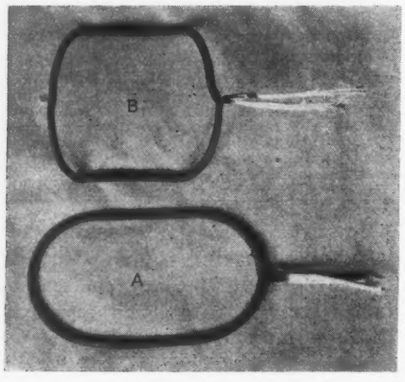
Table IV—Mush Puller Coils for Alternating-Current Stators

(See Figs. 15 to 18)

Symbol	Fig. No.	Model	Coil Making Directions	Operations
M-P-1	15	Plain	Wind on shuttle with single-cotton-covered and enameled wire. Tape or sleeve leads and tie in four places while winding. Bring out leads at diamond point. Pull to shape.	Make shuttle and puller blocks, wind and pull.
M-P-2	16	Tied	Same as M-P-1 except leads are tied with a thin flax or linen thread while pulling.	Make shuttle and blocks, wind, pull and tie leads.
M-P-3	17	Ends taped and leads tied	ame as M-P-1 except that lead end diamond point is taped with 0.004-in. cotton tape ¾-in. either side of loop and leads tied with two or three turns of cord.	Make shuttle and blocks, wind, pull, tape and tie.
M-P-4	18	Ends taped	Same as M-P-1 except both ends are taped with 0.007-in. cotton tape, starting ¼-in. to ⅝-in. on bottom slot section and finishing on top end ⅓ the distance from top cell to front loop.	Make shuttle and blocks, wind, pull and tape.

When winding any type of mush coil with tension on the wire, it will be noticed that there is a considerable bulge on the straight parts. Do not pound this bulge out while winding, as it helps to relieve the tension at the corners after the coil is in place on the machine after taping or after pulling.

The above point can best be illustrated with the mush pulled coil. Fig. 25 shows a mush puller coil just off the shuttle. Note the bulge in the center of the coil between the cord bands and also note how tight the ends are around the pins. This is shown also in Fig. 26, which is a close-up view of the lead end of the coil in Fig. 25. This photograph shows how the wires spread out as they get past the tie cords towards the center of the coil. Then Fig. 27



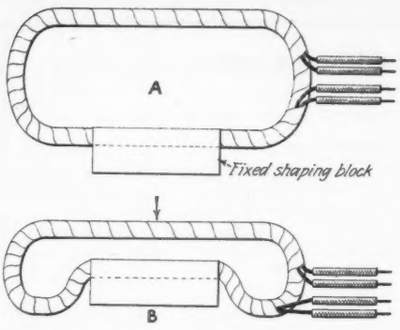
Figs. 22 A and B—These are pulled types of coils for bipolar armatures. The coil is wound and taped as shown in A. It is then pulled to the proper shape, as in B.

shows the same end as shown in Fig. 25 after the coil has been pulled to shape. Note how the wires around the pin have loosened up and spread apart.

The reason for this is that, when pulling, the blocks used to hold the slot sections are a tight fit, thus forcing the wires together and pressing the slack out to the ends. With taped coils the tape forces the slack out on the ends. With untaped coils the forcing of the wires in the slot also chases the slack out to the ends. Therefore, the bulge is helpful and should not be pounded or ironed out in any way while winding mush coils.

In Figs. 26 and 27 tape should be applied to the leads of a.c. coils, a thin (.0045-in.x$\frac{3}{4}$-in.) tape being used, edge-lapped.

Taping of Mush Coils.—There is quite a knack in applying the finish



Figs. 23 A and B—These diagrams show the extra shaping required in making the coil shown in Fig. 22.

tape to all types of mush coils. The tape must be applied semi-tight; that is, tight enough so that it will not slide nor appear baggy, and then again it must not be too tight or all the slack in the wire will be forced ahead of the tape with the result that at the end of the taping operation when near the starting point, the wires will bulge out. It will then be found impossible to pull these bulging wires into the same size as the rest of the coil without twisting and crossing the wires, which is not only troublesome, but is likely to damage the insulation.

Another reason for semi-tight tape is that the majority of mush coils require considerable shaping while winding the armature. In the slot sections it is necessary in some cases to flatten the coil sides with a pair of pliers. Therefore if the wires are held tight by the tape, any attempt to shape the coil would tend to chafe the insulation on the wires and thus cause short-circuits.

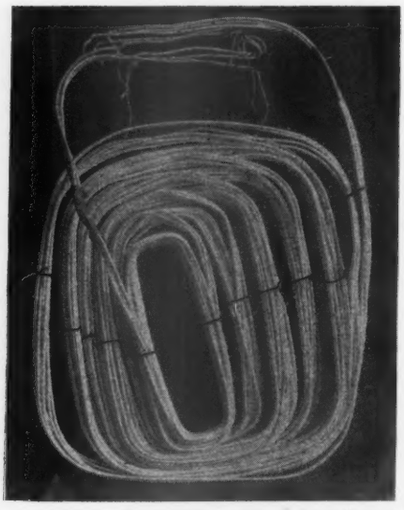
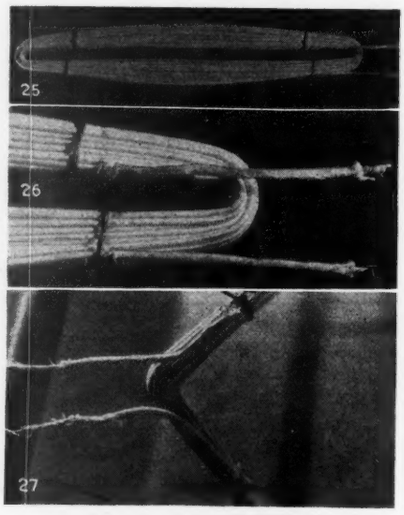


Fig. 24 — Complete pole-phase group wound on gang mold without cutting the wire.
These coils are for a large, single-phase motor.

On mush coils that have only the ends taped, particular care must be taken not to pull the tape too tight, as all the slack will be forced into the slot section of the coil and when the coil is wound into the machine the close fit of the wires in the slot section will force all the slack out to each end of the slot, creating a bulge that increases the chance for grounds or shorts.

Molds for Mush Type Coils.—The simplest mold is the one used to wind flat mush coils. It consists of three pieces: a base, a center block, and the outside plate. The base in most cases is made of 1-in. wood and the center block can be cut from fiber up to $\frac{1}{4}$ in. thick, and above



Three views of a mush puller coil.
Fig. 25—Note how tight the ends are, and the bulge in the sides between the cord bands. An enlarged view of the end of this same coil is shown in Fig. 26. In Fig. 27 the same coil end is shown again after being pulled, illustrating how the wires at the end have loosened up and spread apart.

$\frac{1}{4}$ in., from wood. The outside plate is also made from wood. One thing to watch is to have all surfaces level and when fastening the center block to the base, be sure that all corners fit down tightly against the base. Otherwise, the wires will pull down between the center block and the base or front plate.

To make it easy to remove coils after winding, the two corners close together on the center block should be tapered slightly, the low side being toward the outside plate. If this is done the coils can be slipped off without difficulty.

Coil shuttles will be described in a later article. Some types of flat mush coil molds are shown in "Rewinding Small Motors," by Braymer and Roe, already referred to.

1927

This is a New Year and you are going to do bigger and better things in new and more resourceful ways. Here is a suggestion that will benefit you and others who are working with you, without your knowing it.

AS TIME is recorded, we are at the beginning of another twelve-month period and the things we do and the results we accomplish in 1927 will be compared according to custom with the best of the results for a similar period already passed through. As all of us accumulate knowledge and experience, we should be able not only to secure better results from routine work year by year, but be able to assume larger and more difficult responsibilities. To learn to do one or two things better and better as time goes on is an index to progress, but to those with ambition and initiative this is not enough. Ambition that carries with it vision, and initiative that carries with it confidence born of experience, force us ahead to explore new fields of operation and new ways to make hard jobs easy for the worker and less expensive for the employer who pays his wage.

Every operator who has been engaged in practical work for ten or fifteen years and elevated himself to a position of responsibility can look back and put his finger on several things that helped him forge ahead to a better position and an advance in salary. And in this review of the past he can recall, not one, but dozens of times when a little help on a tough problem would have prevented mistakes and perhaps speeded up the progress that was made.

Not long ago I heard an operator define an "expert" as an ordinary man away from home. This definition is a little deep, but if you think a bit you can probably recall conversations with such experts in which the big "I" and little "you" formed the main thread of the discourse. Such bragging these days does not come from men who do things worth while, simply because their work and their results do not need the advertising of the braggart. There is, however, one effective way to record the results of hard work and advanced thinking on operating problems: namely, by writing articles for publication in journals like INDUSTRIAL ENGINEER, read by operators in far-flung kinds and sizes of plants.

AT THE beginning of this New Year, my message to all operators is to read more and compare their results and ways of doing things with those of other operators in other kinds of plants. Then determine to write at least one general article during the year on some problem you have spent a lot of time on. Give details of how the problem came up—the conditions and equipment involved, what you set out to do and just what you did step by step in working it out, with all the changes, revisions and mistakes made, together with the results that were finally accomplished. Such an article will mean a lot to you for it will furnish a record of your way of handling a troublesome job. But it will mean a lot also to others who may be in the midst of just such a problem and have secured results by another method. Such an article will inspire others to write similar articles and by the end of 1927 you will get back through these articles more than you have given, if you apply and profit by the information thus secured. After all it's helpful co-operation these days that solves the big problems—not bragging about your single-handed part in their solution, as the expert who is an ordinary man away from home, sometimes does.

By the way, the February issue of INDUSTRIAL ENGINEER will contain just such articles as I have referred to, for it will be a special number in which operators will give details of the things they have accomplished during 1926. Read all of these articles and then if you can give some experiences or ways you have accomplished similar or better results, I know that the editors of this publication will be glad to hear from you, if it is no more than a letter indicating that you have read the articles in the February number and plan to write something later.

Let's get better acquainted during 1927 right from the start. Those who have written me, and there are hundreds of you now on my list, write again and again. Those who have not written—well make the February issue an excuse and I'll promise to make it easy for you to write often afterward. Will you do that?

Practical Pete

P.S. *Don't forget the prizes offered on this page in the December issue. You have done something, probably many things, worth while during the past year. Put the facts on paper: if you are busy never mind the English or the grammar. The prizes are for facts, not culture, and the facts told in your own way will get just as much consideration as though they were written by a college professor. Just write and tell what you have done, how you did it, and what you accomplished thereby.*

P. P.

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories
G. A. VAN BRUNT, *Editor*

We Wish You Happiness and Success in the New Year

IN THE rush of the day's work, with its problems and triumphs, vexations and joys, there is oftentimes little opportunity to pay much attention to the other fellow or concern ourselves as to how he is faring: to extend a helping hand or thank him for service that he may have been able to render us. However, the passing of the old year affords a convenient moment for pausing to recall with pleasure and gratitude those with whom we work and to whom we are indebted, and wish them well.

The Editors take this opportunity to thank the readers of INDUSTRIAL ENGINEER for their co-operation and support, in the many ways in which these have been shown during the past year, and to extend every good wish for a New Year filled with Health, Prosperity and Happiness.

Where Does Your Plant Stand in Regard to the Power Question?

SECRETARY HOOVER, in his annual report to the Department of Commerce, states that during the period covered by the report there has been an increase in power consumption of between five and six million horsepower in mills and factories. During this period there has been comparatively little increase in the number of boilers and engines installed in these plants; in other words the increased power consumption is accounted for by the operation of electric motors on purchased power. Mr. Hoover further states that there has been a change from the use of direct-connected steam-engine-driven equipment in mills and factories to the generation of electric power for distribution throughout the plant, so that at the present time 70 per cent of all factory-generated power is delivered to the machines electrically.

This report emphasizes two trends which have been many times pointed out and advocated by INDUSTRIAL ENGINEER: namely, the electrification of steam-engine-driven mills and the increased use of purchased power in mills and factories. Electrification of all steam-engine-driven mills is a foregone conclusion and it is only a matter of time before it will be completely accomplished. The use of purchased power in place of factory-generated electric power is still the subject of argument in many plants. At the present time it is becoming standard practice to use purchased power, except in locations where power cannot be purchased from utilities generating it in large quantities, or where there are waste products from factory production, such as blast furnace gas, coke breeze, lumber waste, and the like, which can be utilized only at the point of production, or in cases where low-pressure steam is required for process work in the factory.

Where does your plant stand in regard to these trends of the day? Is it hesitating and lagging behind, or is it abreast of the times? Power cost often forms a good share of the cost of production; hence frequent check-ups on the cost of power at your plant can certainly not be called a waste of time.

Let Good Judgment Govern Procedure When Experience Is Lacking

THE often-heard saying, "If a little bit is good, more is better," doubtless has a certain amount of truth in it, and probably most of us apply it to a greater extent than we realize. It is not difficult, however, to cite many instances where this saying does not hold true.

One such instance is in the application of belt dressings. Altogether too often belt dressings and preparations of one sort or another are applied so frequently and liberally to leather belts that their efficiency and even their life may be seriously affected. The proper use of a good, prepared dressing will do a great deal towards keeping a belt soft and pliable, and preventing slipping and cracking. The application of surface dressings in amounts sufficient to build up a heavy coating is not only a waste of money, but a definite, and common, form of abuse. Using too much belt dressing is just about as bad, and perhaps worse, than not using any.

Lubrication of bearings is another instance of where too much of even a good thing may be harmful. In many cases the bearings on motors and other equipment are provided with gages that show the oil level, and are put there for the purpose of making it easier to lubricate the bearing properly. Oil or grease are absolutely essential to the operation of all except a few special types of bearings, but to fill a bearing full of oil, regardless of the manufacturer's recommendations, is simply inviting trouble. The excess oil usually flows out and may cause a great deal of trouble, as when it gets on motor windings, for instance.

Erroneous practices and notions regarding the operation and care of equipment are not difficult to find, and are mostly due to ignorance or lack of experience. In addition, every operating engineer is frequently confronted with puzzling problems and situations. In all such cases, a liberal application of the quality of mind known as "plain horse-sense," will do much to prevent mistakes that may easily be explained, but should nevertheless not be made. In few callings is there greater need for plenty of "horse-sense" than in operating and maintenance work. The operator who has it and uses it will find that it will save him from many an embarrassing situation.

Measure the Value of Your Equipment in Terms of the Service It Renders

AT THE beginning of a new year most organizations take stock of their assets and possessions to find out where they stand in a business way. In an industrial plant every piece of equipment is duly recorded, depreciation is calculated, and when all of the figures have been added up and the totals put down the job is considered to be finished. The figures obtained in this way ostensibly show the physical value of the plant, and can be used for a variety of business purposes.

An inventory of this character is both necessary and useful, but from the maintenance and operating standpoints it may fall far short of presenting vital information regarding the physical conditions, operating efficiency and so on of the equipment. During the past few years great strides have been made in the design and construction of almost every type of equipment. Something new is coming along nearly every day. The unusual or unheard-of five or ten years ago is the commonplace of today—and most of the equipment and many of the methods used today will be obsolete five or ten years from now. Wherefore, it comes about that a piece of equipment may be obsolete long before it actually wears out, assuming that it is given anything like proper maintenance attention.

Take the time some day to study a few of the important items of equipment in your plant and appraise them on the basis of their worth and efficiency as compared with the money-saving service that can be obtained from the latest designs now available. Unless the plant has been in operation for only a comparatively short time, or has recently been re-equipped, it will not be surprising if many items almost automatically list themselves as liabilities rather than assets.

Apply Electrical Power Instead of Manpower for Handling Materials

CLOSE competition between industrial concerns make reductions in manufacturing costs of utmost importance. To alert operating men who are on the lookout for opportunities to suggest money-saving ideas, we suggest that one of the most fertile fields for making cost reductions is in the methods of handling material. These are receiving more attention today than ever before because of a decreasing wage differential between the so-called unskilled or common laborer and the semi-skilled worker. Also, due to the immigration restrictions, the former surplus in the supply of common labor no longer exists. This condition has been felt most in the increased cost of the labor for material handling.

Big opportunities are ahead for those who use power-driven equipment for the transportation of material, and many industrial plants are taking advantage of them. For example, in actual installations one storage-battery truck or tractor has replaced from two to thirty-five men in different industries and types of service. An average saving per unit of truck installed is estimated as approximately five men. The installation of conveyors, hoists, tiering machines, hand-lift trucks, and other equipment of this character has also shown worthwhile savings.

How much equipment will the annual wages of five men buy, maintain and operate? What will its installation mean in the reduction of overhead and other costs? These are questions which every operating man should ask and seek until he finds the answer. He will then have the facts on which he can talk dollars-and-cents, which is the best language to use when persuading the management that it is sound economy to purchase equipment that will more than pay its cost by the savings it makes in the payroll.

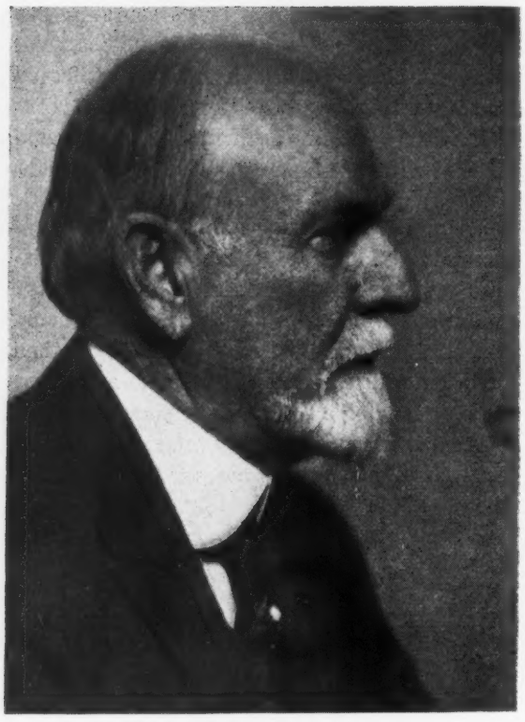
"Put It in and Forget It" May Be Taken Too Literally

FREQUENTLY an equipment salesman clinches his arguments on the dependability of his products by boasting, "After you put this in, you can forget about it." Such statements sound convincing and may be true, *if* the equipment is serviced properly. There is practically nothing about an industrial plant that does not require some attention either at short or long intervals. Bearings, for example, are often intended to be oiled only at long intervals and "forgetten" the remainder of the time.

Servicing of fire-fighting equipment in particular should not be forgotten, although it is one class which is often neglected. Many of the portable extinguishers will corrode so that they will not discharge, if left too long without emptying and refilling. Also, a unit may be discharged and, if left empty, may cause a serious loss. Even though the equipment is in perfect condition, it may be hidden or access blocked by a temporary condition or poor housekeeping. Particular attention should be given to the possibility of freezing (some extinguisher solutions freeze—others do not) when kept in exposed locations, such as unheated warehouses or storerooms.

Safeguards, also must not be forgotten. Otherwise, they may be removed, or be rendered inoperative, or not function properly because of neglect to make the necessary adjustments. Safety requires continuous vigilance not only toward keeping the idea before the men, but also in the provision and inspection of the safeguard.

Servicing, especially where it is necessary only at long intervals, requires that it be placed on a routine or schedule, otherwise it may be forgotten entirely. Does your maintenance department have a schedule for such inspections, or are they on a hit-or-miss (with too many cases of miss) basis? The first of the year is a very good time to establish the proper routine for such work.



JAMES H. MCGRAW

Engineering and Industry Pay Tribute to James H. McGraw

A RARE testimonial was given to a career that began at a country school teacher's desk, when more than 1,000 leaders of engineering thought and accomplishment and industrialists of note assembled in the grand ballroom of the Hotel Astor, New York, on December 17, to commemorate James H. McGraw's 41 years of service as a publisher, on the occasion of his sixty-sixth birthday. Thomas A. Edison, as honorary chairman, headed a distinguished list of those who sponsored the testimonial. These included among others, Secretary of Commerce Herbert Hoover; Gen. Guy E. Tripp, chairman of the board, Westinghouse Electric and Manufacturing Co.; Gerard Swope, president General Electric Co., and Owen D. Young, chairman of the board, General Electric Co.

John W. Lieb, vice-president and general manager of the New York Edison Co., was toastmaster. Before he called on the speakers chosen to represent various business and professional interests, Mr. Lieb sketched Mr. McGraw's career briefly, dwelling for a moment on the comprehensive nature of the McGraw-Hill publications.

Willits H. Sawyer, president of the American Electric Railway Association, was the first speaker. He told what Mr. McGraw's counsel and leadership had meant to the electric railway industry, recalling that the publisher's first journalistic venture had been in the street railway field 40 years ago. This industry, he said, in spite of temporary adversity, must and will go forward. The McGraw-Hill papers have pointed the road to constructive co-operation and co-ordination in the transportation field. He called the guest of the evening a "fountain of well-directed enthusiasm" and read a testimonial to him on behalf of the A.E.R.A.

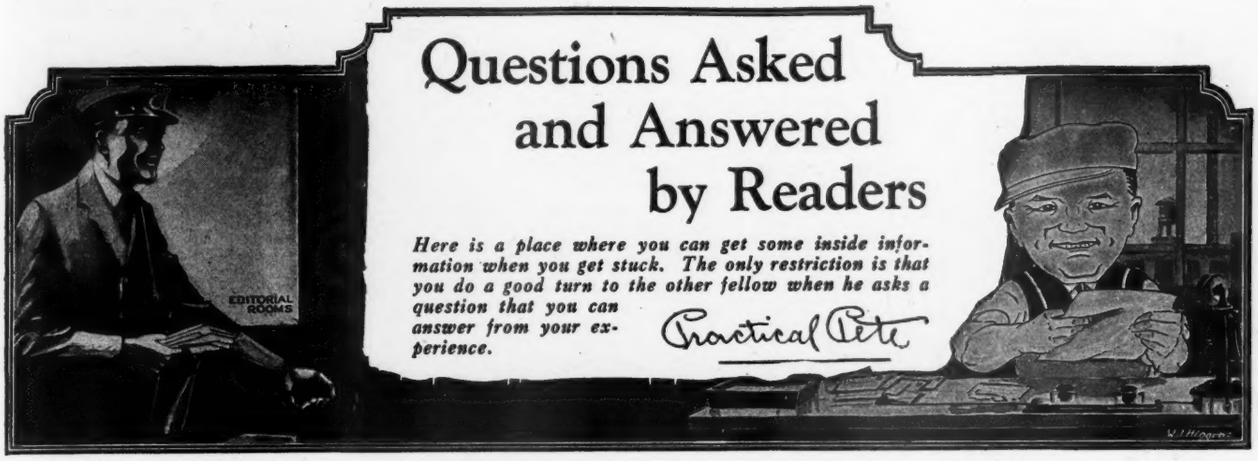
Gen. Guy E. Tripp, chairman of the board of directors of the Westinghouse Electric & Manufacturing Co., who was called on to represent the manufacturing interests, refused, in a witty speech, to "catalog" Mr. McGraw, but referred to him as a "practical philosopher." Idealism was one of the foundation stones on which the publisher had built.

Charles L. Edgar, president of the Edison Illuminating Co. of Boston, remarked that business publications might be classed as good, bad and indifferent. The McGraw-Hill papers, it was his conviction, fell into the first class. Constructive, forward-looking, they had rendered a real service to the electrical industry, and central-station interests were glad to be able to express publicly their appreciation of the leadership exercised by Mr. McGraw.

Dexter S. Kimball, dean of Sibley College, Cornell University, speaking on behalf of the engineering profession declared that the greatest guaranty of the permanency of present civilization is the printed record we are making of the experiences and processes of applied sciences. In that this civilization differs from its predecessors. And Mr. McGraw, he said, was an integral part of the picture because publication of these records was the work of the McGraw-Hill companies.

The last speaker was Edward J. Mehren, vice-president of the McGraw-Hill Publishing Company, representing the publishing industry. He outlined the business principles of Mr. McGraw which are found exemplified in his many publications. He said that an ardent spirit of service, of faith, vision, courage, and perseverance were the qualities Mr. McGraw has brought to bear on the work of his organization.

Responding, Mr. McGraw attributed any accomplishment of his to two things—capable and loyal associates and the support of the professions and industries represented at the dinner. He expressed in warm terms his gratitude to the engineers and industrialists of America and asked for their continued co-operation. When he had fought, he said, he had done so without passion. His sole objective was accomplishment, and when an objective was attained there was no room for bitterness or jealousy over the apportionment of credit. Optimism, Mr. McGraw observed, is an essential of leadership. There must be faith that sincere and earnest work will be rewarded. Edited in this spirit, industrial papers will not only be human, but vibrant with life and imbued with the ambition of high service. In his more than 41 years of work he had seen the civilized world made over. He rejoiced in the engineers and industrialists, and the marvels they had wrought. Three score and six years, he declared in conclusion, had no terrors for him. It was no time to retire but to press on to further endeavor, repaid by the fascination of work—the "joy of the job."



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Checking the Alignment of Lineshafts.—I have always heard that in checking the alignment of a shaft, the belts should be thrown off. It seems to me that the belts should be left on the pulleys to give the approximate operating conditions. In other words, a belt may draw a pulley and shaft and its bearing to one side in operation, but if the belt is off, the shaft may appear to be in line. I believe that the alignment should be checked as nearly as possible under operating conditions. I wish some of our readers would discuss this question.
Moline, Ill. H. J. K.

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Power Factor of Transformers Feeding a Resistance Load—We have two 700-kva., single-phase, 25-cycle, 11,000/220-volt Allis Chalmers transformers with an impedance of 58 per cent that are to be connected in open delta to feed a 400-kva. annealing oven which is heated by resistors. All the impedance in each transformer will be removed down to 12 per cent, which is the limit. Will some reader please tell me what the efficiency and power factor of the transformers will be when they are operated in this manner.
Keokuk, Ia. L. M. S.

* * * *

Reducing D. C. Voltage—Current for operating our signal systems is now supplied by two motor-generator sets; the demand on the generators varies from 15 to 20 amp. at 15 to 20 volts. We wish to discard our motor-generator sets and I should like to know of some suitable method of reducing the voltage on our 110-volt, d.c. service line so that we can operate our signal systems from it. It has occurred to me that a water rheostat might be suitable for this purpose. If so, can some of the readers give me the data for such a rheostat? Can anyone suggest a better method?
Chicago, Ill. M. G.

* * * *

Size of Alternator Required for Industrial Plant.—We wish information on selecting capacity of alternators for small a.c. power plants for industrial use. (1) Recently we had to calculate the size of generator required to drive two 175-hp., 80 per cent power factor, three-phase, 60-cycle, 257-r.p.m., 440-volt, synchronous motors direct-connected to ammonia compressors, and three or four small, squirrel-cage induction motors aggregating 60 hp. The generator was required to be able to start one synchronous motor at full line voltage when the other synchronous motor was already developing full capacity. What generator capacity would be required to handle this load?

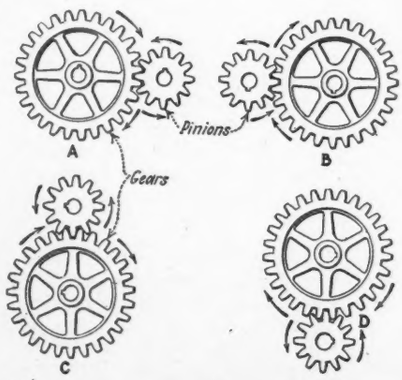
(2) Another recent case involved the electrification of a small factory. There were about ten 5-hp. motors, four 10-hp. motors and two 25-hp. motors, all squirrel-cage induction motors; the lighting load was about 5 kw. and there was one passenger elevator requiring one 7½-hp. motor. It was desired to have the three-phase, 60-cycle, 220-volt generator direct-connected to a crude oil engine. What capacity of generator would be required in this case? In arriving at the size of generator required, is it enough to add the various full-load currents of the motors and use this as the size of the generator? How do we take into consideration the power factor and the inrush current taken by the motors in starting? How can we be sure that the voltage will not drop very much so as to cause flickering in the lights when the motors are started, especially when the elevator is operating?
Lima, Peru. A. B.

* * * *

Locating Trouble in Conduit Wiring—We have an extensive system of conduit wiring in our buildings and underground, which takes care of 440-volt power and 110-volt lighting service lines. This system was installed several years ago, and since then certain changes and additions to the plant structures have rendered long sections of the conduit very inaccessible. At various times faults have occurred in the wiring which were very difficult to locate. I wish some of the readers would tell me the best methods of locating grounds and shorts, and also suggest the best ways of testing and checking the condition of the wiring, so that we can detect and locate weaknesses before they become serious.
Providence, R. I. G. F. H.

* * * *

Location of Motor Pinion.—Is there a preferred location of the motor pinion with respect to the driven gear? The accompanying diagram shows four different drive arrangements, one having the motor pinion on top of the driven gear, another with the pinion at the bottom, and others with the pinion on either



side of the gear. The direction of rotation of the gear and pinion is indicated by the arrows. Which of these locations is preferred from the standpoint of stress on the motor frame and on the foundation bolts, lubrication of gear and pinion, and ease of maintenance and inspection? Are they all equally good? I should like to have some of our readers discuss this question, and give me the benefit of any experience they may have had with such a problem.
Landgraff, W. Va. U. J. S.

Answers Received To Questions Asked

What Size of Belt Is Required for This Drive?—A 15-hp., 1,750-r.p.m. motor is used to drive a punch press. The pulley on the motor is 6 in. in diameter and the driven pulley is 40 in. in diameter, the distance between centers of the motor and press pulleys being 15 ft. I wish readers would give me some information regarding the adaptability of leather belts to this drive. Specifically, what width of leather should be used to give the best results? Should this belt be single or double-ply? Would you advise the use of some other type of belt and if so, what kind and why?
Rockford, Ill. R. W. A.

Answering R.W.A. I would say that a leather belt is quite the proper thing for this type of drive. A 4-in. heavy, single belt (16-18 oz. or $\frac{3}{16}$ in. thick) would be perfectly satisfactory for this drive. A 5-in. medium single belt (14-16 oz. or $\frac{5}{32}$ in. thick) would answer just as well. The choice between these two would depend upon local conditions, such as the face of the pulleys, moisture and general driving conditions.
Fort Worden, Wash. E. I. PEASE.

* * * *

I would recommend a single leather belt for R. W. A.'s punch press drive. The question does not state the width of the pulley face, or the material of which it is made. If the pulley is made of paper or similar material a 6-in. single belt will easily transmit 20 hp. at this speed. The pulleys are closer together than some authorities consider good belt practice. According to F. W. Taylor, as given in Kent's Mechanical Engineers Pocket Book, from 20 to 25 ft. is the best distance for shaft centers. He also states that a leather belt will last from 7 to 13 yr. under ideal conditions. Double belts should not be run over pulleys under 12 in. in diameter.
GRADY H. EMERSON.
Birmingham, Ala.

* * * *

Under the conditions specified in R.W.A.'s question our belt tables would call for a 3-in., light-double, first-quality leather belt. This would include due allowances for the unfavorable operating conditions involved in the high peaks in the punch press load and the undesirable pulley ratio. However, our experience with punch press drives has shown the advisability of heavily over-

belting this class of work. We would advise using a light double belt at least 5 in. in width and wider if the pulleys are wide enough to permit it. Our service records show that the increased cost of this wider belt will be quickly offset in increased production, especially if a grade of belt with high overload capacity is used.

R. R. TATNALL.

Experimental Engineer,
J. E. Rhoads & Sons,
Wilmington, Del.

* * * *

R.W.A. asks for information regarding the proper thickness and width of a belt driving a punch press from a 15-hp. motor with a driving pulley 6 in. in dia., at 1,750 r.p.m. He does not give the horsepower which is actually transmitted, but we presume that his motor is not overloaded. The accompanying table gives the horsepower that solid woven belting will transmit per inch of width in the single, double and triple thicknesses at various belt speeds. Figures given in this table are for drives where the arc of contact is about 160 deg. or over. The inquiry does not state whether the drive is horizontal, vertical or inclined. If it were a horizontal drive with an under pull, the arc of contact would be increased.

Velocity in f.p.m.	Single	Double	Triple
200	0.31	0.55	0.73
400	0.63	1.15	1.45
600	0.94	1.70	2.18
800	1.2	2.25	2.88
1,000	1.5	2.80	3.58
1,500	2.2	4.15	5.33
2,000	3.0	5.45	6.88
2,500	3.6	6.65	8.30
3,000	4.2	7.70	9.60
4,000	5.0	9.50	11.40
5,000	5.3	10.50	12.05

The belt speed is about 2,750 f.p.m. and by consulting the table we find that a double belt will transmit about 7 hp. per inch of width. However, the service mentioned requires a margin of safety, and we believe that a 4-in. double belt would be satisfactory.

CHARLES HATHAWAY.

Stanley Belting Corporation,
Chicago, Ill.

* * * *

The following suggestions may help R. W. A. in the choice of the proper belt to meet his conditions. The use of a leather belt is to be recommended, I believe, unless the location is damp or the belt is to be subjected to extremes of heat and cold. A leather belt, if well selected and properly handled should last for 20 yr., and even then, if the worn parts are cut off the remaining portion may be used for a shorter drive. In the selection of a belt the quality of the leather should be the first consideration. The leather should be firm, yet pliable, free from wrinkles on the hair or grain side, and of an even thickness throughout.

In this case, as the motor pulley is small, a single belt would be best. Where double belts are used on small pulleys, the contact on the pulley face is less perfect than it would be if a single belt were used. More work is required to bend a heavier belt as it runs over the pulley than in the case of the more pliable single belt. The centrifugal force tending to throw the belt from the pulley also increases with the thickness.

A belt should be sufficiently wide to withstand safely, and for a reasonable length of time, the greatest tension that will be put upon it; this will be the tension of the driving side when starting under load. The safe tension for single belts may be taken as 60 lb. per inch of width; single belts average $\frac{3}{16}$ in. in thickness.

The tension on the driving side, however, is not the force tending to turn the pulley. The force tending to turn the pulley, or the effective pull, is the difference in tension between the driving side and the slack side of the belt. The tension on the driving side depends on three factors: the effective pull of the belt, the co-efficient of friction between the belt and pulley, and the arc of contact of the belt on the smaller pulley.

The arc of contact may be determined approximately as follows: Measure the circumference of the small pulley. Stretch a string over the two pulleys to represent the belt. Take another string, hold one end at the beginning of the arc of contact, as shown by the string stretched around both pulleys, wrap it around the smaller pulley, and cut it off at the end of the arc of contact. The arc of contact in degrees is found by dividing the product of 360 times the length of the string representing the part of the belt in contact by the circumference of the pulley. The following table shows the effective belt pull allowable for various arcs of contact.

Arc of Contact in Degrees	Allowable Effective Pull in Lb. per Inch of Width
90	23.0
112½	27.4
120	28.8
135	31.3
150	33.8
157½	34.9
180 or over	38.1

To find the width of a single leather belt for transmitting a given horsepower, use the following rule:

$W = (33{,}000 \times \text{hp.}) \div (V \times C)$

where W = width of single belt in inches; $hp.$ = horsepower to be transmitted; V = velocity of belt in feet per minute; and, C = allowable effective pull per inch of width from the above table.

In this case the belt speed is rather high, but this is not a bad fault because the higher the speed of the belt, the less need be its width to transmit a given horsepower. The belt speed is approximately 2,750 r.p.m. $(3.1416 \times 6) = 18.85$ in. = circumference of motor pulley. $18.85 \times 1{,}750 \div 12 = 2{,}748$ f.p.m.

As it is almost as easy to find the arc of contact by the simple method of measurement as previously explained as to compute it by formulas, the following rule may be used at present for finding the width of the belt, and R. W. A. may later measure the arc of contact and substitute the values in the preceding formula. For single belts multiply the horsepower to be transmitted by 33,000 and divide the product by the speed of the belt in feet per minute multiplied by 38.1 (for 180-deg. arc of contact), thus: width = $(15 \times 33{,}000) \div (2{,}750 \times 38.1) =$ 4.75-in. belt. The nearest commercial width is 5 in.

It will be found, however, that the formula that uses the actual arc of contact as one of its values will give more accurate results. ARCHIE L. FORGER.

Chief Electrician,
G. A. Head Electric Co.
Laconia, N. H.

* * * *

Changing Speed of Direct-Current Motor—We have a General Electric, Type CO 15, form A, four-pole, compound-wound, 230-volt, 15-hp. motor, serial No. 124206. This motor is rated at 55.5 amp. and a speed of 625 r.p.m. The actual no-load speed, however, is very close to 800 r.p.m., due possibly to some repairs that have been made to the armature winding. Will some reader kindly tell me how I can decrease the speed of this motor to 550 r.p.m.? We would like to make this change in speed by some manipulation of the fields rather than rewinding the armature.

Hannibal, Mo. R. E. G.

In reply to R.E.G.'s question, it does not seem likely that he will be able to make so great a change in speed without rewinding the armature. There are several methods for reducing the speed of a d.c. motor.

If there is sufficient air gap between the armature and field poles, this may be reduced by shimming under the field pole faces, that is, between the field core and the frame. If the bearings in this motor are in good shape, the air gap may be made very small, with a gratifying reduction in speed.

Another method of reducing the speed would be to insert resistance in the armature circuit, being careful to insert it in such a place that it will not affect the field. The speed may also be varied by moving the brush yoke, but it may be shifted only as far as proper commutation will allow.

Any of these methods or a combination of all three will decrease the speed of the motor and at the same time will, of course, affect the efficiency. It seems to me that it might be well for R.E.G. to purchase a new motor of the specifications he desires providing, of course, that he can either use this motor in a different location or perhaps trade it in.

Cleveland, Ohio. G. H. WINTERSTEEN.

* * * *

In reply to R. E. G., the speed of a direct-current motor may be increased or decreased about 10 per cent by increasing or decreasing the air gap between the armature and field. If the change in speed must be accurately determined, a magnetization curve of the design of this individual machine will be necessary. As a general rule, where the change in speed is not too great, adjusting the air gap will produce the desired results with but little experimenting. There are some cases, however, where the motor is designed to work high up on the saturation curve and the iron is practically saturated, or perhaps very low down on the saturation curve and the excitation is nearly all used up in the air gap.

Reducing the air gap reduces the speed and increasing the air gap increases the speed, although decreasing the speed is usually the easier to accomplish. To reduce the speed, thin steel shims are placed next to the frame, using the same number under

each pole piece. The amount of change that can be made in this manner depends upon the length of the original air gap.

If a great enough reduction cannot be obtained in this way, a further reduction may be gained by placing resistance in series with the armature. This resistance reduces the voltage impressed upon the armature winding, as the speed of the motor is proportional to the applied voltage. This is a sure way of reducing the speed, but it is an inefficient method.

Indianapolis, Ind. M. V. MILLER.

* * * *

Replying to R.E.G., about the easiest and cheapest way to reduce the speed of a motor is to shift the position of the brushes, but the amount that the brushes can be shifted is, of course, limited, by its effect on the commutation. Where the load is constantly varying or fluctuating it is, of course, not possible to shift the brushes constantly in accordance with the load variation. Due to the fact that increased field strength will reduce the speed of the motor, more wire or turns may be added to the shunt field coil.

A compound motor may be made to run at constant speed, if the current in the series winding of the field is arranged to act in opposition to that of the shunt winding. Then an increase of load will weaken the field and al'ow more current to flow through the armature without decreasing its speed. Such motors are, however, not very often used, since an overload would weaken the field too much and thereby cause trouble. If the current in the series field acts in the same direction as that in the shunt fields, the motor will slow up slightly when a heavy load is put on, but wi'l take care of the load without much trouble.

Motor speed may also be reduced by inserting resistance in the armature in the form of a speed regulator, the amount of speed reduction depending partly on the amount of resistance introduced into the armature circuit and partly upon the load. The maximum amount of speed reduction is about 85 per cent when employing a resistance in series with the armature circuit, but a reduction as great as this is unsatisfactory, for a comparatively slight increase in the load will cause the motor to stall. The reason the motor runs more slowly in this case is because part of the energy is shunted into the resistance and there dissipated in the form of heat. Whether the motor is operating at full speed or half speed, the amount of current consumed is about the same; in one case all the energy goes into the motor, and in the other some of it is dissipated as heat in the resistance. This objection is partly offset by the fact that speed reduction by the armature resistance method can be applied to any motor of standard design and requires nothing more than a simple and inexpensive speed regulation rheostat. When a motor runs at full speed most of the time, one may feel justified in using the armature resistance method. It may be that R.E.G.'s motor runs faster now after rewinding the coils because the armature winder put fewer turns in each coil, so that he could gain more space in the slots.

District Line Supt., H. J. ACHEE.
Southwest Light and Power Co.,
Elk City, Okla.

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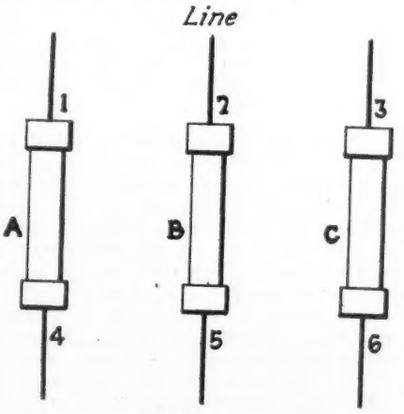
Testing Fuses to Prevent Motors Running Single-Phase—We have a large number of three-phase induction motors that are protected by individual fuses placed near each motor. Also, the different branch circuits feeding several motors are protected by fuses. To insure that the motors do not operate single-phase, frequent tests are made of the fuses. Is it sufficient to test the fuses by temporarily connecting a lamp of suitable voltage across the ends of each individual fuse? Will a lamp test across the phase wires ahead of or after the fuses give a positive indication? Will connecting the lamp ahead of one fuse and behind the adjacent fuse give a reliable indication? I should like to have some of the readers discuss these questions for me and point out which is the best method to use for testing under the conditions described and also tell how to interpret the different indications obtained from the lamp.

Newark, N. J. W. S.

While considering W.S.'s question, the writer could not see how lamps could be used to determine whether a three-phase induction motor is running single-phase, because the windings of the motor which are not carrying power current would generate an electromotive force nearly equal to line voltage. This slight difference between the voltage generated in the open phase and the line voltage would not cause sufficient difference in the illumination of a lamp to be readily detectable by the eye. A voltmeter was thought to be a possible indicating instrument for the above condition and a test was made in the laboratory with a 5-hp., 220-volt, three-phase induction motor.

Referring to the accompanying illustration phase *A* was opened while the motor was running (circuit breakers were used instead of fuses, but the conditions are exactly similar). Connecting a 300-volt voltmeter to measure the line voltage across points *1-3*, *2-3* and *1-2* gave a reading of 236 volts in each case. Measuring the motor voltages, *4-5* gave 215 volts, *4-6* gave 215 volts, and *5-6* gave 236 volts. This indicated that the motor was running single-phase and because the low reading of 215 volts resulted whenever a measurement from point *4* was made and the normal reading of 236 volts was obtained in the combination not employing point *4*, the indication was that line *A*, or circuit breaker *A*, was open.



This shows the points across which the voltage was measured to detect a blown fuse in a three-phase circuit.

A further test was made employing the same voltmeter, by measuring the voltage drop across the circuit breakers. In this measurement, *1-4* gave a slight indication on the voltmeter, estimated at about 15 volts, while *2-5* and *3-6* gave no indication. This second method indicated that circuit breaker *A* was open. This second method is probably the easier and quicker of the two methods. In all such tests, a voltmeter whose full-scale deflection is at least as great as the line voltage, should be used. In the first method, the line voltage readings across *1-2*, *1-3* and *2-3* should always be obtained in order to detect any line voltage unbalance, which if not known, might cause misleading values for the motor voltage readings.

All of the above voltmeter connections were repeated with a 220-volt lamp in place of the voltmeter, but the writer could not detect any difference in the illumination of the lamp and hence could not determine the open line by employing a lamp.

In the rather infrequent case of two fuses blowing, these fuses could be located by means of a lamp of line voltage rating. In this case connect the lamp from one of the motor ends of the fuses in turn to any one of the other line terminals, as for example *4* to *2* or *3*, *5* to *1* or *3*, and *6* to *1* or *2*. If the lamp lights, then the fuse in the line to which the lamp is connected on the motor side of the fuse is good and if the lamp does not light, it is not good.

Instructor, H. A. MAXFIELD.
Worcester Polytechnic Institute,
Worcester, Mass.

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While running a test on a 3-hp., 220-volt, three-phase induction motor, to ascertain certain information relative to W.S.'s question, I obtained the following data:

In order to distinguish between the fuse connections, the terminals of the fuses in phases *A*, *B* and *C* will be referred to as *1*, *2* and *3* respectively on the line side and as *4*, *5* and *6* on the motor side.

When the motor was not running, a reading of 228 volts was obtained between points *1* and *2*, 228 volts between points *2* and *3*, and 226 volts between points *1* and *3*. During normal operation of the motor, 227 volts was indicated between points *1* and *2*, 226 volts between points *2* and *3*, and 224 volts between points *1* and *3*.

While the motor was running single phase, 206 volts were indicated between terminals *4* and *5*, 224 volts between *5* and *6*, 202 volts between *4* and *6*, and 15 volts between *1* and *4*.

Two 220-volt, 60-watt carbon filament lamps connected in series were used in the same manner as the voltmeter. When the lamp terminals were placed across points *5* and *6* the lamps were lighted at half brilliancy. When the terminals were placed across points *4* and *5* and *4* and *6* a difference in the brilliancy of the lamps was easily detectable. When testing with one lamp only, a greater difference in the brilliancy of the lamp was noted. The same lamp test was repeated on a

5-hp. motor running slightly loaded and no trouble was experienced in locating the open phase. R. V. MARTYN.
Auburn, Washington.

* * * *

Thawing Frozen Water Pipes.—I should like to obtain data for building a transformer drawing about 600 amp. on the secondary side, which is to be used for thawing out frozen water pipes. The transformer is to be used on a 115-volt circuit and I shall be grateful if some reader will let me know the size of core to use, the size of wire, and the number of turns on the secondary and primary windings. What should the secondary voltage be, in order to give the best results for my purposes?
Duluth, Minn. F. G. G.

In answer to F.G.G., I am giving the data for a 2-kw., 115-volt, 60-cycle transformer, with an output of 150 amp. at 13 volts, on the secondary side which I believe will serve his purpose.

The sheet-iron core should measure 17⅛ in. long by 8¾ in. wide, outside dimensions. The thickness and breadth should be 3 in., or 3 in. square.

The primary winding should consist of 80 turns of No. 8 B. & S. gage d.c.c. magnet wire, wound in even layers on one of the long legs of the core, which has been previously well insulated with several layers of Empire cloth.

The secondary coil is wound on the other leg of the core and should have nine turns of No. 0 B. & S. gage magnet wire. Owing to the difficulty of winding No. 0 wire, it would be advisable to wind either two No. 3 or four No. 6 wires, connecting them all in parallel to form a single wire. The efficiency of this transformer is about 95 per cent. R. W. BUCKETT.
Richmond, Calif.

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Substitute for Crane Collector Bars.—We are having considerable trouble with the collector bars on a floor-type charging crane used for charging skelp into a heating furnace. These collector bars are placed below the floor level and are reached by a collector rigging operating through a slot in the floor. We propose to do away with this method, because of maintenance troubles, and substitute a multi-conductor cable which will run from the crane to some fixed point nearby. Can some reader tell me how to rig up a device for retrieving this cable so as to prevent it from being dragged over the floor or catching on objects placed on the floor? The total travel of the crane is about 25 ft. and the cable must not be carried higher than 10 ft. in the air for there are cranes working overhead that might interfere with the cable.
Gary, Ind. F. U.

I should like to call F. U.'s attention to the automatic take-up reel manufactured by the Appleton Electric Co., Chicago, Ill. These people manufacture reels for multiple-conductor cables, which are used in connection with various types of equipment, such as locomotive cranes, foundry equipment and electric overhead traveling cranes and hoists. C. E. SCHIRMER.
Chief Engineer,
The Toledo Crane Co.,
Bucyrus, Ohio.

* * * *

F. U. will probably find, with such a short crane travel, that a piece of Tirex cable will answer his purpose admirably. This cable may be installed by attaching it to a few insulators which are strung on a slide wire. The cable will sag between the insulators in a series of short loops, but not enough to dip down in the way. The cable should be fitted on both ends with separable connectors which would open or come apart in case of an accident or a hard pull on the cable, and thus prevent breaking it or the slide wire.
Electrical Engineer, R. P. DIEHL.
Park City Mining & Smelting Co.,
Park City, Utah.

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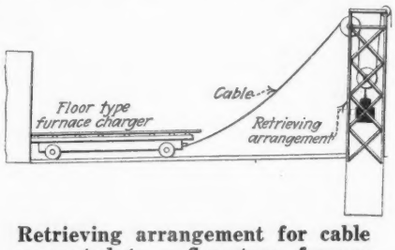
In connection with F. U.'s floor-type furnace charger which has a 25 ft. travel, I believe that collector shoes on contact rails below the floor level could be arranged to give the most satisfactory results. However, if a flexible cable is to be used for conveying energy to the motor on the machine, a multiple cable with rubber outer surface, such as Tirex made by Simplex Wire and Cable Co. or Super Service made by the Rome Wire Co., should suffice.



Retrieving arrangement for cable connected to a floor-type furnace charger.

These types of cable will stand dragging over the floor, but as small objects may be placed on the floor, in the way, it is suggested that the cable be run from the charger over a sheave mounted at the top of an angle-iron structure not more than 10 ft. high, as shown in the accompanying illustration. A movable sheave carrying a counterweight should put sufficient strain on the cable to keep it off of the floor as the charger moves toward the retrieving arrangement. Because of the limitation in headroom, the counterweight will have to go below the floor level, but the pit need not be more than about 4 ft. deep.
Pittsburgh, Pa. D. W. BLAKESLEE.

* * * *

Lubricating Ball and Roller Bearings.—I wish to know how thin an oil can be satisfactorily used to lubricate ball and roller bearings used in motors. Do readers prefer the use of grease for these applications and if so, why? What are the desirable characteristics of oils and greases that are intended for use on the roller bearings and ball bearings used in motors?
Youngstown, Ohio. E. L.

In regard to the question asked by E. L., the lubrication of ball bearings on different motors should be studied, as I find that one grade of oil is not suitable for all the motors in our plant. A medium grade of oil, containing a small amount of graphite, may be satisfactory on one installation, while on another where speed may be somewhat slower, a lighter oil is generally found more satisfactory. If there is any doubt concerning the lubrication of a particular motor, it might be well to communicate with the manufacturer of the motor concerning the proper lubricant to be used.
Chief Electrician, E. J. MORRISSEY.
United Gas & Electric Co.,
Aurora, Ill.

How Many Men Are Required for Maintenance in This Plant?—I wish readers would tell me how many men we should have for carrying on the electrical maintenance and repair work in our power house. This plant is a central station isolated from other companies and is self-dependent. It has five generating units: one 20,000 kva., two 6,000 kva., one 3,500 kva., and one 3,200 kva. There are four exciters, two rotary converters, and two 550-volt commercial d.c. generators. The plant also contains three banks of bus tie transformers as well as three 33,000-volt transformers. There are 121 motors ranging in size from ⅛ to 200 hp. at 220 and 2,300 volts, and also a 44-panel switchboard with auxiliary switchboards as needed. This plant has automatic control and interlocking systems and is modern in every respect. Some of the apparatus is three years old. We expect to handle all repair work such as winding and testing, as well as any new installation work that may be required. I am chiefly interested in the number of men required and the particular work that should be assigned to each. Your opinions will be very helpful.
Aurora, Ill. E. J. M.

Referring to E.J.M.'s question, it would seem advisable in my judgment to have the following maintenance men: One electrical superintendent in charge of all maintenance, repair, testing, and installation work; one shop foreman in direct charge over all members of the personnel, two experienced winders, one for a.c. and one for d.c. work (all repair work on motors other than re-winding is to be done by these men also); three experienced testers (a.c. and d.c.) to do testing and general repair work and maintenance on equipment in place; three electrical helpers to work with testers and develop into experienced men; two laborers or plant men to clean equipment, truck motors from location to shop, and be generally useful.

This personnel, naturally, will be enlarged from time to time as requirements develop and this outline is given as a start, or as a skeleton working crew to handle the equipment outlined. Additional duties should be given each man when conditions make this advisable.

The superintendent can be eliminated, if necessary, but one man should be held responsible for the entire work in this department. As a rule, a superintendent will have plenty to do devising methods of procedure, plotting equipment locations, developing a renewal parts file, and the like and also supervising the care of the equipment of the system. I would strongly advise that this position be created as it forms the backbone of the entire organization in the plant.

Under this set-up the shop foreman would, of course, report to the electrical superintendent, and the foreman in turn supervises the laborers or plant men, winders and repair men, and testers and testers' helpers. If outside electrical men are included in the personnel they should have the chief of the crew report directly to the superintendent as a matter of routine.

Of course, a cut-and-dried organization can not be developed on paper, and experience will determine, largely, the extent and duties of the personnel. As the equipment is up to date and practically new no serious trouble should develop and I believe the above crew would be adequate.
NATHANIEL W. BLANCHARD.
Inwood, L. I., N. Y.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Effects of Overvoltage on Contactor Coils Reduced by Using Reactors

VARYING line voltage is the source of considerable trouble with the operating coils of contactor.

These devices are often abused by imposing on them voltages above their rating, with the result that the insulation becomes baked, making a breakdown inevitable. When it is necessary to use an outside source of current, whose voltage is higher than the coils are designed for, or when the voltage of the plant supply is too high, it is well to provide some means of bringing this voltage down to meet the requirements of the contactor coils.

A 5 per cent variation from the rated voltage is all that coils should be called upon to handle, and if the voltage of the supply circuit is more than 5 per cent too high or too low, trouble will likely be encountered sooner or later.

I recall an installation which was put in a few years ago, where the coils were designed to operate on 440 volts, but the supply circuit was badly overtaxed with varying loads, causing serious voltage fluctuations at the coils that resulted in burned-out coils. This fluctuation, which ranged from 480 to 500 volts, amounted to a minimum overvoltage of 10 per cent and occasionally rose to 13 per cent or more. The coils in question were contactor coils on a Westinghouse automatic synchronous motor panel. Outside service of decidedly poor character was used and the fluctuations were due to an overloaded system feeder carrying 60-cycle a.c. current.

To protect the coils a reactor was chosen in preference to a resistor, partly because we had no resistor on hand, whereas the parts for a reactor were available.

The number of turns required for the reactor was first based on a guess. After the reactor was connected up the voltage of the supply circuit and at the coil terminals of the coils was checked by a voltmeter. The difference in the readings was divided by the number of turns in the reactor which gave us the correct value per turn, after which we added enough turns to obtain the result desired.

The contactors operated by these coils weigh about 350 lb. per panel. There were four panels per board, or a total of six panels, including the operating panels.

As we were not designers of reactors, we measured the area of the iron in the contactor core and put the same amount in our reactor.

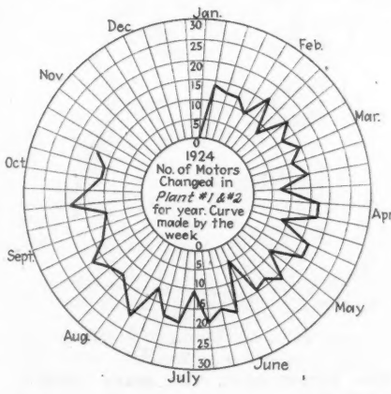
The iron core was obtained from a discarded transformer and probably could not be considered the best, but it served our purpose. The number of turns to be used was another item that a designer could state in a few minutes, but in our case we experimented with wire the same size as that used in the contactor coil, until we were satisfied. The voltage was cut to the proper value, and thereafter no more coils were destroyed.

As ours was but a temporary arrangement, the iron was stacked in the usual manner, but in the form of a square, in order to use the iron without cutting. The corners were held together by C clamps and the unit was supported by glass-insulated spools.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.,
Aurora, Ill.

Method of Recording Number of Motors Removed

IN THE electrical department of a plant having about 1,500 motors operating under severe conditions, a chart was made up to record the number of motors removed for any and all causes, in order to observe graphically the trend of plant conditions and amount of work performed. A circular chart was selected for convenience and a tracing is made once a year in ink on tracing cloth; then the necessary blueprints are made up. The curve showing the number of motors changed is filled in weekly for the office record with red pencil. At monthly intervals the tracing is inked in and after blueprints are made they are sent to the officials interested. The inside circle on the chart is 2½ in. in diameter, the radius of the circle being increased 1 in. for every ten motors. The chart may be conveniently laid out with an engineers' scale and compass.



This chart is used to record the number of motor removals.

The various points on the curve are plotted weekly.

J. ELMER HOUSLEY.
Electrical Engineer,
Aluminum Company of America,
Alcoa, Tenn.

Low Voltage Supply Cause of Puzzling Motor Trouble

SOME time ago one of the electricians in our shop was sent to a bottling works to find the cause of trouble on a pump motor. This motor was a 15-hp., 220-volt, 1,800 r.p.m., a.c. machine and was made by a reliable manufacturer. The pump was of the centrifugal type and of a well-known make, and was direct-connected to the motor through a rigid coupling.

The electrician who examined the motor was a capable man and made all kinds of tests for the source of the trouble, which appeared to be unusual. The motor started normally and ran all right without load, but when the pump discharge valve was opened, it slowed down perceptibly. Although the motor was not overloaded it would begin to heat immediately and in 10 or 15 min. was abnormally hot. Without a doubt, the motor would have burned up in an hour or so, running with load.

The electrician tested for bad contacts in the starter, in the line relays, and main switch; any contacts that looked at all loose were tightened and the motor leads were also gone over. When these efforts did not eliminate the trouble, mechanical defects were looked for. The bearings were examined and found to be low. The rotor was removed, new bearings were made, the rotor replaced, and the pump and motor shafts carefully aligned. This remedy did not bring the desired results; so a machinist was sent to examine the motor and pump for mechanical defects. He checked each part carefully but found nothing wrong.

It was then decided to send another man over to look at the motor and see if he could find the trouble. Anyone who has dealt with such troubles knows that a man can stay on a job like this one until he becomes fagged out and cannot do his best work. The second man comes fresh on the job, with all the facts the first man found, and has only to check these facts before proceeding with his own ideas or experiments. Any man who "shoots trouble"

knows that oftentimes his results are gained by cut-and-try methods, especially when the trouble is obscure. He probably finds some minor trouble, corrects it and tries the mechanism to see if it functions properly; if it does he makes several trials to make sure that it did not just happen accidentally. If it functions properly every time, the chances are that he has remedied the trouble; if not, further investigation is necessary.

The second man sent had an ordinary magneto and a 220-volt test light. To satisfy himself he made all the tests that had been previously made. Finally he tested the voltage with his test light, as he did not have a voltmeter. The light burned brightly and apparently the voltage was normal. It then occurred to him to leave the test light on the switch and start the motor. With the motor running the test lamp burned a dull red.

This man at one time worked for the power company and knew several of the foremen; so he asked the foreman in charge of this particular district to come and test the voltage.

When a meter was attached to the switch it showed about 212 volts, with the motor at rest. But when the motor was started and the load put on, everyone was surprised to find that the voltage supply had dropped to 160 volts. The power company agreed to make transformer changes that would eliminate the trouble, and also to increase the line voltage or make any other changes necessary to deliver the power required.

When these changes were made the following day, they brought us another small job. A single-phase motor at a bakery ran hot; in fact, it smoked. The man who solved the bottling works trouble was sent to this job, and with voltage testing fresh in his mind made the same test and found the voltage at the motor to be 220. This motor was wound for two voltages, with the leads brought out in the usual way, and had been connected for 110 volts. The 110-volt connection probably was made when the 220-volt supply dropped to 160 volts. When the motor was reconnected for 220 volts it operated satisfactorily.

GRADY H. EMERSON.
Birmingham, Ala.

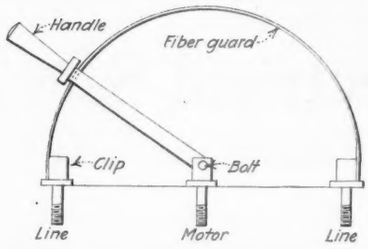
Method of Using Fiber Guard to Prevent Arcing Between Switch Blades

ANSWERING an emergency call from our substation, one night, I found that the operator had a badly burned arm, and a rotary converter motor starting switch was burned up.

A few questions brought out the fact that the operator had been cleaning the converter and, desiring to give the armature a half turn, he had momentarily closed the motor switch.

As the motor was rated at about 25 hp., 400 volts, and had the whole 1,500-kw. transformer bank back of it, the thoughtless closing of the switch resulted in an arc that was brief, snappy and directly to the point.

To avoid a repetition of this accident, barriers were made up from ¼-in. black fiber in the form of a half circle, and



This knife switch is equipped with fiber barriers to prevent arcing between blades.

then were mounted between the switch blades in such a way that the crossbar of the switch would just clear the barriers, as shown in the accompanying illustration.

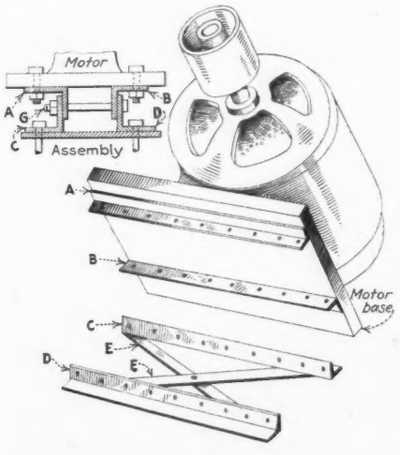
As a further precaution, a hole ⅞ in. in diameter by ¾ in. deep was bored in the armature shaft near one end, and a heavy spanner wrench was furnished so that there would be no inclination to "inch" the armature with power.

Electrical Engineer, PHILIP N. EMIGH.
The Mountain Water Supply Co.,
Indian Creek, Pa.

Simple Method of Constructing Improvised Motor Base

RECENTLY an emergency job made the installation of an additional motor necessary. Although a motor of the proper size and speed was found to be on hand, no suitable slide rails or base could be located. There was no time to await the arrival of a base from the manufacturer; so it was necessary for the electrical crew to devise a substitute base. Eventually the base, shown in the illustration was built.

This base consists principally of two pieces of 3-in. by 3-in. angle iron which were cut 20 in. long, and two pieces of 4-in. by 4-in. angle iron each cut 24 in. long. Four bolt holes were spaced on pieces *A* and *B* so as to match up with the holes in the frame of the motor. The other holes in these two pieces, *A* and *B*, were spaced 1½ in. on centers.



The motor base was made from angle iron.

A and *B* are pieces of angle iron 3 in. wide by 20 in. long. *C* and *D* are 4 in. wide by 24 in. long. Two bolts, *G*, secure the motor in a position after the belt has been tightened.

These two angle irons were then bolted to the motor, as shown.

The 4-in. by 4-in. angle irons were braced by pieces of strap iron, *E* and *F*, the holes in the other flange of these angles being spaced 2 in. on centers. After assembling the various parts of the base, it was then easy to take up belt slack ½ in. at a time, due to the difference in the spacing of the holes in the vertical parts of the angles, one set being spaced 1½ in. apart and the other set 2 in. apart. Two bolts, *G*, were used to hold the motor in place, after taking up slack in the belt.

This device was quite satisfactory, except when we had to take up slack in the belt, for it was then necessary to use a jack to draw the motor back so that the bolts, *G*, could be inserted. However, a screw to take up the slack could easily have been added, although it was not done on the job just described, for a new slide base had been ordered and would eventually take the place of this arrangement.

Chief Electrician, CHAS A. PETERSON.
U. S. Gypsum Co.,
Alabaster, Mich.

Comment on "One More Reason for Standardizing General-Purpose Motors"

WE HAVE been much interested in your editorial published under the above head in the October, 1926, issue, and also in the various comments made on it. Our company, a number of years ago, realized that the many changes in designs of motors reacted most unfavorably upon the user; hence in bringing out our Type T direct-current motor in 1915 we laid down a policy that any future improvements made in this motor must be interchangeable with the original design in mounting dimensions as well as be capable of utilizing the spare parts used on older types of motors, and which the user might have in stock.

The success of this policy was demonstrated at the Philadelphia Convention of the Association of Iron and Steel Electrical Engineers in 1925. Here was exhibited the first Type T motor shipped from our factory in 1915. Beside it stood a duplicate motor, just off the test floor. Many improvements in design were noticeable. Brush-rigging, field and armature construction, bearing enclosures, and other parts had been kept up to date in every respect. In spite of these changes, every part of the two motors could be interchanged. Spare parts bought in 1915 could be applied to the 1925 motor.

It was comparatively easy to follow the same policy on alternating-current motors, and since our Type AA line of squirrel-cage motors was developed in 1920, we have been successful in making improvements in design and manufacture that have not affected the interchangeability of the parts of our product.

Our customers have commended us so highly on this policy that we intend to adhere to it and give them what we believe to be real standardization.

President, CLARENCE C. COLLINS.
Reliance Electric & Engineering Co.,
Cleveland, Ohio.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Experiences with Anti-Friction Bearings in a Flour Mill

IN OUR 2,400-bbl. flour mill, all of the rolls, scourers and separators are equipped with ball bearings in order to eliminate friction, and, after 12 yr. of service in charge of this mill, I can frankly say I am a friend of the so-called anti-friction bearings, because they save power, oil, and a large amount of labor which would otherwise be required to repair the machines and keep them clean and well oiled. Also, the rolls are always running cool, which means continuous operation and results in more and better production every day. The ball bearing has come to stay, I believe.

We are in a progressive age and are always looking for something better, although after 12 yr. of continuous operation, night and day, I now have over 75 per cent of the original ball bearings in use and these are still giving good service in spite of the constant jar and vibration a flour mill roll bearing is subjected to. For the past 2 yr. I have been trying out some of the Hoffman roller bearings, and so far they have given good results. I like the principle of the roller bearings and believe that they are better in certain places especially where the bearing is not rigid but is subjected to a continued jar and vibration, because it has more contact, both on the inner and outer races. Ball bearings have a point contact and roller bearings have a full line contact, according to the length of the rolls. Within a few years I think practically all machines, at least in my industry, will be equipped when built with either ball or roller bearings because they operate better, last longer and are cheaper in the long run than plain bearings. Also, their use results in big savings in power, oil, and labor, and, in addition, the flour machine will last much longer. In our industry labor is the greatest operating expense and we are always trying to reduce it wherever possible. Power expense is the next big item with us and the improved bearings help to reduce it. This mill is consuming less than 5.5 kw.-hr. per bbl. which includes all power used in the mill elevators, all light, and a considerable amount of heat in the office and laboratory.

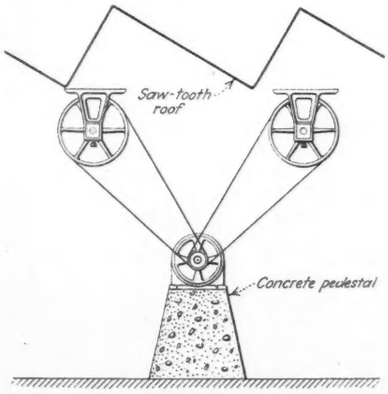
Men in charge of industrial operation should study their power consumption per unit and compare it, if possible, with other plants. Even with a favorable comparison they should investigate thoroughly all equipment to discover any unnecessary losses. In many cases they would find that if they would install improved bearings and take other measures to reduce the power loss that they are paying for each year, the savings would make it a good investment.

Superintendent, J. HANSON.
The Wichita Flour Mills Co.,
Wichita, Kan.

Method of Driving Two Shafts from One Motor

THE more common method of connecting two lineshafts to be driven by a single motor is to belt the motor to a jackshaft, which is usually placed between the two lineshafts, and drive both from it, or to belt the motor to one shaft and drive the other shaft by belt from the first. The first plan requires the erection of an additional jackshaft, while the second method requires that the first shaft be heavy enough to take the full load, although half of it may be transmitted directly to the second shaft.

The accompanying illustration shows a third method of arranging a single motor drive for a pair of parallel lines of shafting which is used at the Poughkeepsie, N. Y., plant of the DeLaval Separator Co. These shafts are located in a single-story building with saw-tooth roof and the lines of shafting follow the valleys of the roof, with the machine tools aisled off in a similar manner. Each pair of shafts is driven by a single d.c. motor, which is located alongside the main longitudinal aisle at one side of the room and at the end of the shaft. Each motor is mounted on a substantial concrete pillar, as shown in the sketch, which lifts the motor above the floor dust and high enough to be safely out of the way of passing traffic. The pulleys are higher than the head of a tall man, but still not too high to be convenient for giving any necessary attention to the motor. Testing, oiling and inspection can be carried out by standing on a light portable platform without the risk and time loss that accompany work from a ladder.



Group drive arrangement for driving two lineshafts from a single motor.

By mounting the motor on the concrete pedestal, it is raised above the floor line, so that it is not likely to be damaged by passing trucks. However, the motor is not too high to be easily accessible.

It is usually considered poor engineering to run two belts off the same pulley or to operate belts in such close proximity, chiefly owing to the chance of their fouling. However, no difficulty has been experienced and the belts keep on running safely year after year with not more than an inch between them. One reason for this satisfactory operation is because the heavy driving belts are kept in good condition and so do not run wavy or deviate from a single path of travel.

Advantages of Using Oilless Bearings on Loose-Pulley Drives

OILLESS bearings, which do not throw the lubricant, particularly wood bearings like the Arguto, have found considerable favor in textile and food plants. Many master mechanics will object to classing wood bearings with metal, so far as life is concerned, and will, perhaps, back up their claims by data on countershaft loose pulleys with wood bushings and with some form of metal bushing operating under similar conditions.

Often the wood bushing does not last so long as those made of metal, but a study of its use in the textile industry brings up a point worthy of consideration by master mechanics in many other lines. In this discussion, mainshaft bearings or split bearings are not considered.

The wood bushing has the advantage of taking all the wear, and does not wear the shaft. In the cotton and the silk mills, many machines are driven by clutches and through three-pulley drives, in which a loose pulley is placed between two tight pulleys, one of which is driven by a crossed belt. Often, the clutch drives are direct from mainshaft to machine.

A loose pulley on a mainshaft or the loose pulley in a three-pulley drive will wear the shaft smaller in time, depending upon the speed, the load, and the material which is in contact with the shaft. When this occurs, there is no good way of bringing back the original

fit; although the pulley or the clutch is bushed, the inside diameter has to be large enough to pass over the original shaft size and then when it gets to its position it is a poor fit because the shaft under it is worn.

One remedy is, if possible, to turn down the shaft from the cleared-up loose-pulley position to the end and make the loose-pulley bushing to fit When this is done, one of the tight pulleys has to be bushed down also. Where this practice is followed the operating men will soon find themselves in a nightmare of odd shaft sizes.

It is because of these conditions that wood bushings have found favor. They become worn, but they leave the shaft of standard size. All the maintenance necessary, after the pulley is removed, is merely a 5-min. session on the arbor press. Added to this, is the saving in time through not stopping to oil up, and the freedom from damage to textiles through the absence of oil dripping. For these reasons many operators will find it to their advantage to investigate the possible uses of wood bearings in their industry particularly where oil damage is a serious factor. There are of course, other ways of overcoming this difficulty with loose pulleys, but most of them require scrapping the existing equipment.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Power Grease Gun for Outside Use in Cold Weather

APPLYING lubricants to a number of back-geared motors using a heavy oil or grease is an operation that takes considerable time, particularly where the casing has been cleaned out and is to be refilled. This problem is especially difficult in cold weather. In addition, if done by ordinary methods, the greaser usually gets as much oil or grease on the outside of the machine, and on himself, as on the inside. This surplus lubricant, which is seldom removed properly, catches dust, particularly in dust-producing plants, such as in the lumber industry with which I am connected. Dusty or greasy gear cases not only indicate poor industrial housekeeping, but often are not seen by inspectors or others who are likely to brush against the casings and smear the dust-covered grease or oil over their clothes and themselves, which does not tend to improve the disposition of the worker toward the machine.

In the winter months when the temperature is low the difficulty of lubrication is aggravated in that it is next to impossible to get heavy oil to flow through the small openings provided in the casings of reduction gears and other similar equipment.

With the above conditions in mind, the grease gun shown in the accompanying sketch was made up. The actual cost was around $25. The parts necessary for construction were picked up around our scrap pile, which has a duplicate in practically any plant. The main grease cylinder was made from a piece of 8-in. pipe, 26 in. long. This was bored out on the inside to a smooth finish. A plate was welded to the bottom and tapped out at the bottom for the air pipe shown in the sketch.

A ring of ½-in. steel plate was welded to the outside of this cylinder about 8 in. from the top, as shown. The top cover was made from a circular piece of §-in. steel plate which was grooved on the under side to fit over the end of the cylinder. Packing and eyebolts, which fit into the slotted circumference of the plate and are held down with thumbnuts make this top joint air tight, but it can be removed easily for filling.

The piston is made in three parts, with cup leathers in between, and bolted together in the center, as shown in the cross-section sketch at right. These cup leathers are the same as are used in the air cylinders on the logging cars and a supply of them is kept in stock. Once installed, the leathers should last indefinitely.

The piston fits so tightly in the cylinder that it was necessary to use a compression thimble to insert the piston. This thimble consists of a ring about 4 in. wide with the inside diameter at one end the same as the inside diameter of the cylinder. This diameter gradually tapers out, somewhat like a funnel, until it is about 1 in. wider at the other end. This taper assists in forcing the leather cups into the cylinder.

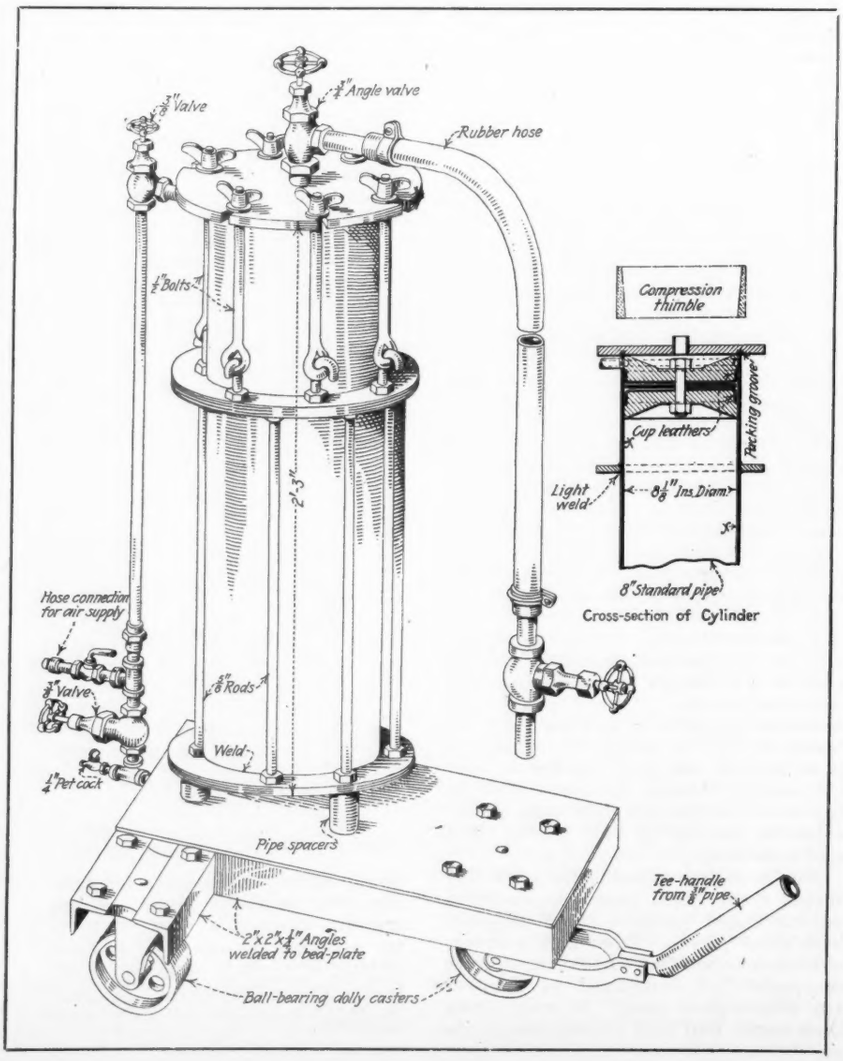
When the gun is empty the piston can be forced to the bottom of the cylinder by air pressure. With the piston at the bottom of the cylinder all valves are closed and the top removed by loosening the thumbnut. This gun holds nearly 4 gal. of oil. Practically all grades of cup grease or 600 W oil can be handled easily.

This cylinder is mounted on a three-wheel dolly with ball-bearing, swivel casters and is fitted with 50 ft. of air hose and 10 ft. of 1-in. grease hose with a reduction to ½-in. opening at the outlet valve for an air pressure of 60 lb. Air pressures up to 125 lb. can be used, but with a smaller grease hose or outlet opening.

WM. B. CONE.
Chief Electrician,
The Shevlin-Hixon Co.,
Bend, Ore.

Construction of a gun for filling oil or grease reservoirs by compressed air.

The cylinder holds about 4 gal. of lubricant which is forced out by compressed air. To fill, push the piston to the bottom of the cylinder by admitting air to top of cylinder. Remove the head by loosening the thumbnut on the eyebolts and fill the cylinder. Replace and tighten the head. To operate, admit air to bottom of cylinder, thus forcing the piston up and the grease out through the end of the hose.



In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Inexpensive Method of Making Varnished Tubing

VARNISHED tubing can be made by a simple method that has proved to be a money saver. The first step to take in the making of these tubes is to cut short lengths of wire or rod 3 ft. in length with a diameter equal to the size of the tubing desired. Common white sleeving, of a size that will fit quite loosely over the wire, is slipped onto the wire. Care must be taken not to pull the sleeving tightly. This is important in order to be able to remove the finished tubing easily after the varnish has been applied.

The next step is to apply the varnish. A piece of pipe 3½ ft. long is fitted with a cap at one end, and filled with a quick air-drying varnish. I find Sherwin-Williams' Ajax No. 19 very satisfactory, as it dries quickly. Shellac can be used, but is not so flexible. The sleeving is first dipped in varnish and hung up to drain and, when dry, it will slip off the wire quite easily. Dip again in varnish, but without the wire core. When the tubing is dry it is ready to use.

There are many places where this tubing can be used to advantage, especially in rewinding stators. Time can be saved by slipping tubing over the group connections, after the winding is all in place, as is commonly done on factory-wound machines. The tubing can also be slipped over the pigtails, instead of taping. Any boy around the shop should be able to make up quantities of different sizes of tubing at very small cost.

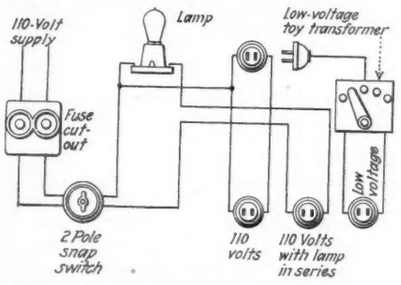
R. BUCKETT.
Richmond, Calif.

Easily-Made Test Panel Giving Choice of Several Voltages

EVERY repair shop requires some form of test board which may be used to supply various voltages used in shooting trouble or otherwise testing repaired apparatus. The test board shown in the accompanying diagram provides a supply of 110 volts, having a lamp connected in series with it, and a low-voltage supply ranging from 20 to approximately 6 volts. This board is made up of very simple apparatus that can be readily obtained in the average shop.

The accompanying diagram shows the layout and wiring for the test board. Protection is provided by means of a fuse cutout, and the power may be turned off the panel by means of a double-pole snap switch. Three plug receptacles are provided under which should be stencilled the voltage of the power supply which is wired into it.

The low voltage is obtained by means of a toy transformer. A bellringing transformer may be used if desired, but in this case only one voltage can be obtained from the transformer. Toy transformers such as are used for operating electric trains provide several voltages by means of a small tap switch and use may be made of this to deliver several voltages.



Here is a simple test panel that will meet the requirements of many small repair shops.

Considering the simplicity and value of such a test board, no small repair shop can afford to be without one.

NATHANIEL W. BLANCHARD.
Inwood, N. Y.

Method of Eliminating Trouble with Rotary Converter Due to Poor Contacts

BECAUSE of an experience which I had with a 1,150-kw. rotary converter, the following account of how trouble was overcome by making good mechanical joints may be of interest to other readers of INDUSTRIAL ENGINEER.

This particular machine would develop black spots on the commutator bars under alternate poles and was subject to sparking. Grinding helped temporarily, but the worst trouble was encountered with the six collector rings. The converter had been repaired several times, but would run for only about six months before it would flash-over and ground. This made it necessary to disconnect all the rings, pull off the hub and sometimes order new rings from the factory.

By inspecting the machine very carefully before stripping, it was discovered that the studs were loosely threaded into the ring and that the connections from the armature coils to the studs were very poor. The vibration of the machine in addition to the expansion and contraction during 24-hr. service caused the joints to work loose. Oxidation of these loose parts was responsible for such poor contacts that some of the studs carried more current than their capacity. The result was poor operation, and when the trouble developed to a certain stage, the studs melted off, causing an arc.

To overcome this trouble the six rings were removed, two being cracked when the arc occurred. As this was a rush job, it was necessary to have these two rings cast in a local foundry and machined in our own shop to save time. All the threads of the old rings were drilled out and the holes were reamed to a uniform taper. New studs were made and tapered to fit snugly in the rings. On the ring end of the studs a thread was cut and a lock-washer and nut put on, which would take up the slack caused by the ring expanding from the heat. This washer assured a mechanically solid joint at all times and good contact without the aid of solder. It is not advisable to rely on solder alone in such cases, and to make sure there would not be any trouble at the contact between the studs and connectors, all of the connectors were drilled and a bolt put through them. In this way we could clamp the connectors to the studs and thus make a good electrical connection.

To give additional mechanical strength, a hole was drilled through both connectors and studs, a bolt put through and the joint soldered. This eliminated the danger of the connectors becoming loose when the machine was running at 1,200 r.p.m. Once a month the machine is stopped and inspected for loose nuts, but so far none has been discovered.

Replacing the rings on the hub of a machine of this size was difficult with the equipment in the average repair shop. We did it in the following manner. It was necessary to put three layers of 0.03-in. and two layers of 0.02-in. molding mica on the hub, which was heated slightly. The first layer of mica was shellacked on and the hub then rolled over a smooth piece of iron. The weight of the hub helped to compress the mica tightly. The five layers of mica were put on in this manner. Steel band wire was then wound over the mica the entire length of the hub. Before the banding wire was fastened a small pulley was slipped over the end. A heavy weight suspended from this pulley served to tighten the wire as it was being wound on the hub. For further details of this procedure see page 409 of D. H. Braymer's book "Armature Winding and Motor Repair."

Heating the hub with a torch helped us to get the mica on solidly. When the hub cooled off, the steel band was removed, the mica sandpapered and six small bands wound on each position where the rings were to set. After this, the bands were soldered and smoothed off in the lathe. The object of the bands was to make certain that the rings would adhere more closely to the mica. By boring out the rings a few thousandths of an inch smaller and shrinking them over these bands, we felt certain that they would stay in position when the machine was in operation, and this proved correct.

All of the old coils were stripped from the rotary, cleaned in a lye tank, retinned and taped by hand. The rotary was rewound, the rings assembled and the machine was back in service within 16 days from date of breakdown. Most of the time four men worked on this job, but never later than 10 p.m. This machine has been operating day and night for about nine months, and is stopped once a month for cleaning and inspection. No signs of black spots on the commutator or sparking have been noticed, which is sufficient proof that the trouble was eliminated.

We have handled similar cases of trouble on other rotaries in the same way and I believe it is safe to say that manufacturers of rotaries could eliminate most of our troubles by paying more attention to the a.c. side, in regard to better mechanical joints before soldering. Repair men oftentimes do not go far enough to determine the cause for failure of a certain machine. If a coil is burned out or a stud burned off he replaces it and considers that is all that is necessary. However, allowances should be made for occasional faulty design or errors which might have been overlooked by the factory inspectors.

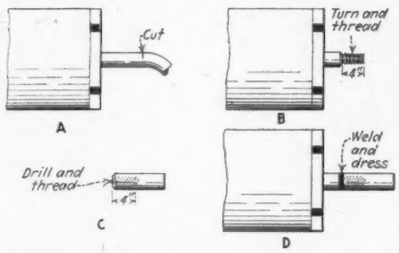
NICHOLAS J. WEISS.

West New York, N. J.

Quick Method of Straightening Emery Grinder Shaft

INSTEAD of waiting for a new shaft from the factory, D. N. Bryan explained in a recent issue of *Suggestions* (The Lincoln Electric Co., Cleveland, Ohio), how the shaft of a motor-driven grinder was straightened at the plant. This shaft was badly bent, due to a tool being caught between the guard and the wheel, the bend in the shaft being just outside of the bearing. The shaft was repaired in the following manner.

The rotor was removed from the motor and the shaft cut just behind the bent portion, as shown at *A* in the accompanying illustration. The remaining shaft was then turned down to about 25 per cent of its diameter for a distance of about 4 in. from the end, as shown at *B*. This part was threaded its entire length and a piece of mild steel, shown at *C*, was turned, drilled and threaded. This piece was then screwed onto the rotor shaft, and at the junction point of the two pieces a V-shaped groove was cut to the same depth that the shaft had been turned down. The groove was then "filled" and the shaft made into one piece by electric welding. After this work on the joint was finished by truing up in a lathe, the emery wheel was ready for service.



This grinder shaft was straightened by replacing the bent portion with a piece of mild steel.

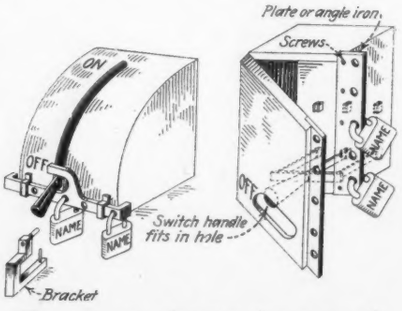
The bent portion of the shaft was cut off, as shown at *A*, the end of the remaining portion of the shaft being threaded, as at *B*, so that a new piece of shaft *C* could be screwed onto it. The two pieces were then welded together, as at *D*.

This method will prove satisfactory for lengthening shafts, as well as for straightening them.

Converting Knife Switches from Enclosed to Safety Type

TWO practical methods of converting the open or enclosed type of knife switches to safety type switches are explained below. The method to be used in a given case will depend primarily on the style of switch housing employed.

A switch fitted with a housing similar to the one on the left in the accompanying illustration can be secured in the "off" position by employing a strap made from ⅛-in. sheet iron bent to the proper shape. This strap is locked in position by means of one or more padlocks, the number depending upon the number of men working at different places on the line controlled by this switch. Just as soon as a man completes his work on the line he removes his padlock, thereby keeping the line "dead" until the last man has completed his work. The strap that holds the switch handle in the "off" position may or may not be bent at the ends, but should have holes in it, to accommodate several padlocks. Each man or group boss should be supplied with a padlock marked with his name, number, or other means of identification, and with a key to fit it.



Here are two inexpensive ways of changing enclosed knife switches to a safety type.

Where the half circular type of cover is used and the switch handle is visible at all times, the switch may be secured open as shown at the left. The box type of cover has a slot in it so that the switch handle can protrude through it when the switch is open.

A switch enclosed by a box similar to the one on the right in the sketch can be secured in the open position by allowing the switch handle to project through a hole marked *OFF* in the cover, the cover being fastened by one or more padlocks. Two pieces of strap iron or angle iron are used to hold the cover closed, holes being bored in the iron to accommodate the padlocks. When the switch handle is seen protruding through the cover of the box there will be no doubt as to whether the switch is open or closed.

Oakland, Calif. S. H. SAMUELS.

Easy Method of Changing Speed of Wound Rotor Induction Motor

SOME time ago it became necessary for us to change the speed of several G.E. motors from 600 to 900 r.p.m. The data on these motors were as follows: Type I, Form M, 150 hp., three phase, 440 volts, 600 r.p.m., rotor winding of the wave type, size of conductor approximately $\frac{3}{32}$ in. by $\frac{1}{2}$ in., two bars in parallel. The winding was connected three-circuit star, and the pitch of the stator coils was 1-and-10.

A definite procedure was followed while changing the speed of these motors. First of all the motors were dismantled, and the stators carefully stripped. The coils were then placed in the spreader and pulled out to give a coil pitch of 1-and-12. The stator was then rewound, the coils being grouped for eight poles, and later connected four-circuit star.

The two outer steel bands on top of the soldered clip joints at the ends of the rotor barrel winding were removed and the varnish thoroughly cleaned off the clip joints. Copper filling pieces, slightly tapered, were then made and after being tinned were driven in radially between the clip joints. These filling pieces formed a light ring of copper on each end of the rotor winding. The cross-section of each ring was approximately $\frac{3}{4}$ in. by $1\frac{1}{4}$ in. These filling pieces were then made into a solid mass by pouring half-and-half solder over them. The steel bands were well insulated and replaced. The slip rings and all the connections thereto were left intact but the brushes and brush-gear were stripped from the motors.

Over a period of about four years' continuous service on ball mill drives, where the load averages 170 hp., these motors have operated very satisfactorily, and without failure. The method outlined above appealed to the writer as being the cheapest and quickest way of obtaining the desired result. This method of changing over the motors has the further advantage of leaving the rotor in such condition that it can be readily changed back to its original condition for 600-r.p.m. operation.

THOMAS JORDAN.

Garfield, Utah.

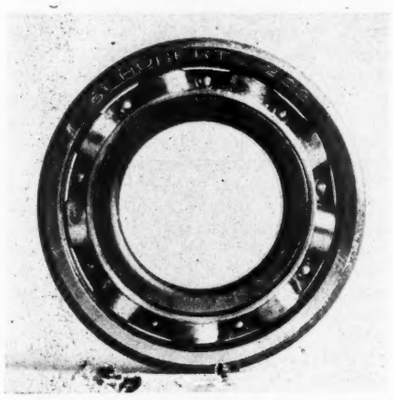
New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Deep-Groove Ball Bearings

MARKETING under the name of Schubert of a new type of deep-groove ball bearing in standard sizes with both double and single row, is announced by the McGill Metal Co., Valparaiso, Ind. One of these bearings is shown in the accompanying illustration. It is claimed that the dimensional tolerances of these bearings have been reduced to approximately one-half of the standard S.A.E. tolerances and that particular attention has been given to the finish of the high-carbon, alloy-steel surfaces of the races and the balls. The bearings are of the deep-groove, non-filling, slot type, which, it is said, are capable of carrying axial or thrust loads in either direction.

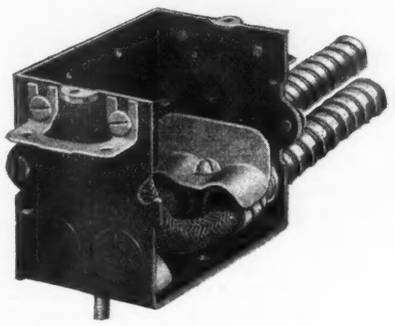


Schubert deep-groove ball bearing

The retainer for the bearings is made of McGill metal, which is a modified aluminum bronze that, it is stated, may be die-cast within very small tolerances and has physical properties closely approximating mild steel. The manufacturer states that the decrease in weight of the retainer, which results from using this metal, is important, especially at high speed. He also states that the high inherent heat conductivity of the bronze tends to dissipate any heat developed.

Adjustable Clamp for Sectional Switchboxes

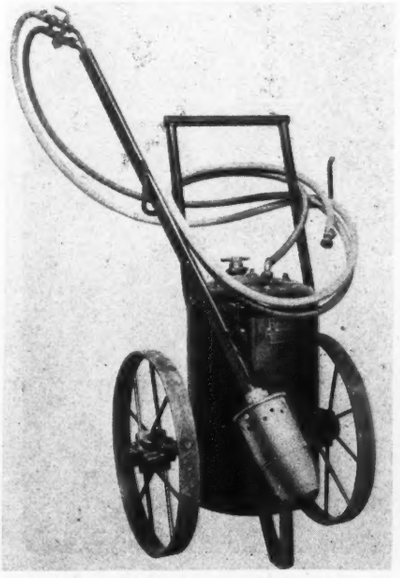
ACCORDING to the manufacturer, the Chicago Fuse Mfg. Co., Laflin and Fifteenth Sts., Chicago, Ill., the clamps on the new Gem XC sectional switchboxes not only secure the sheathed and metallic cable or loom, but at the same time close up any knockout hole space not filled up by the incoming cable or loom. Also, it is stated that this new clamp has an extension so that as the screw is turned down this extension covers the openings, if any, depending upon the size of the cable used. The Gem sectional boxes manufactured by this company which are equipped with this new No. 7 clamp are the XC, the Locktite XCT, and the bracket box XCB. The accompanying illustration shows the XC box.



Chicago Fuse Mfg. Co.'s. Gem XC sectional switchbox.

Preheating Torch

THE portable, two-wheeled venturi suction preheating torch shown in the accompanying illustration is announced by the Hauck Mfg. Co., 126-134 Tenth St., New York, N. Y. The burner is made of sheet steel and pipe, and the nozzle of cast iron. The construction and operation are described by the manufacturer as follows: The tank is made of seamless-drawn, pressed steel, with bottoms interlapped and brazed; all fitting connections are welded.

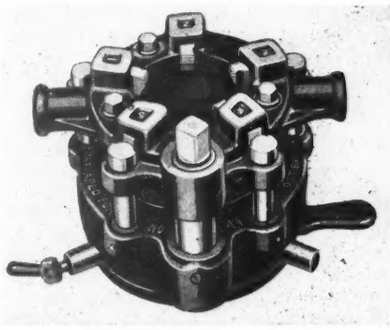


Hauck venturi suction preheating torch.

The torch can be operated 14 ft. above the fuel level in the tank. The torch operates on fuel oil as heavy as 28 deg. Baumé, it is stated, or on all lighter oils and distillates. Only the usual air pressure of 50 to 100 lb. per sq.in. is required. There is no pressure on the oil to the burner. It is asserted that should the oil line be cut, the oil flow stops instantly because suction is broken and that the same is true should the air line be cut. It is stated that the Hauck Venturi suction torches have been approved by the Underwriters' Laboratories, and the Factory Mutual Insurance Company's Laboratories.

Receding Diestocks

DEVELOPMENT of the No. 44 new receding diestock for 2½-in. to 4-in. pipe inclusive, has been announced by The Oster Manufacturing Co., Cleveland, Ohio. The tool is geared and is furnished with a ratchet handle so that, it is stated, one man can cut 4-in. pipe. Other operating features as given by the manufacturer are as fol'ows: A leader screw, protected by a patented chip shield, starts the dies on the pipe and pulls them along. Adjustment for deep or shallow threads is obtained by a rotary movement of the die head. The bore of the stock is large enough to allow a 4-in. coupling to pass through and thus permits the threading of short nipples.



Oster Manufacturing Co.'s No. 44 receding diestock.

Gravity-Lowering Chain Block

MARKETING of a gravity-lowering chain block is announced by Herbert Morris, Inc., Buffalo, N. Y. It is stated that steel plate and forgings are used in its construction. The worm has a double thread and is turned from a solid steel shaft and heat-treated, hardened and ground. Ball bearings are used for the end thrust on the worm shaft. The load-chain wheel and worm wheel are made in one piece. An automatic brake on the worm shaft sustains the load whenever the hand chain is

released. A centrifugal brake keeps the lowering speed within safe limits when lowering by gravity. Over-lowering is prevented by an automatic stop which applies the brake as the hook reaches its lowest point. This unit is rated at 1 ton, but, it is stated, has a considerable margin of safety.

For hoisting only a light pull on the hand chain is necessary. To lower by gravity, a pull on the gravity lowering handle releases the automatic brake. The hand chain does not move when lowering by gravity. However, the load may be lowered by pulling on the hand chain, as is necessary when adjusting a load or when lowering a very short distance.

Illuminating Gas Torch

MARKETING of a gas cutting torch for use with illuminating and by-product gases has recently been announced by The Alexander Milburn Co., 1416-1428 W. Baltimore St., Baltimore, Md.

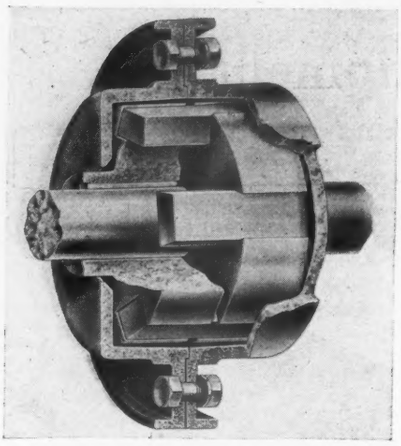
It is claimed that, with city gas costing but one thirtieth as much as other gases, a large saving can be made in fuel gas alone. According to the manufacturers, an outstanding feature of the Milburn Torch is the superheater which heats and expands the cutting oxygen, also the preheating gases, raising the temperature of the cutting oxygen to approximately 100 deg. C. prior to combustion. This increases the temperature of the gases at the torch tip, increases the rate of flame propagation in the burning mixture and, it is stated, reduces the oxygen consumption from 25 per cent upwards. A bunsen burner, contained within the torch, burns illuminating gas which heats the cutting oxygen as it passes through a series of copper coils.

The torch, it is said, is ruggedly constructed of bronze forgings and specially drawn tubing. The high-pressure cutting oxygen is controlled by a thumb valve which remains fixed in either the open or closed position. The torch is 21 in. in length and is supplied with a complete range of tips for light, medium and heavy cutting.

Metallic Flexible Coupling

A NEW design of flexible coupling, shown in an accompanying illustration, is announced by W. H. Nicholson & Co., Wilkes-Barre, Pa., manufacturers of the Nicholson compression coupling. It is a metallic coupling throughout, and does not have any springs, laminated bolts, grids, gears, or disks. The coupling consists of two flanges or hubs, with slotted rims, which are keyed to the shaft, a two-piece shell, and three or five tapered keys to fit into the slots as shown.

The operation as described by the manufacturer is as follows: Shaft misalignments are taken care of by means of the loose-fitting, floating keys, with beveled sides. In the small sizes of couplings three floating keys are used, and on larger sizes, five. When in motion centrifugal force throws the floating keys out into the slots, which, it is stated, causes them to drive quietly and smoothly. When the torsional load comes on, the centrifugal force acting on the floating keys is overcome and they recede to the bottom of the slots. The interior of the coupling is filled with oil. A film of oil is maintained between the keys and slots at all times, allowing a free lateral float of the coupling hubs. This coupling, which is made for all sizes of shafts and all conditions of service, is described more fully in Bulletin 1026 issued by this company.

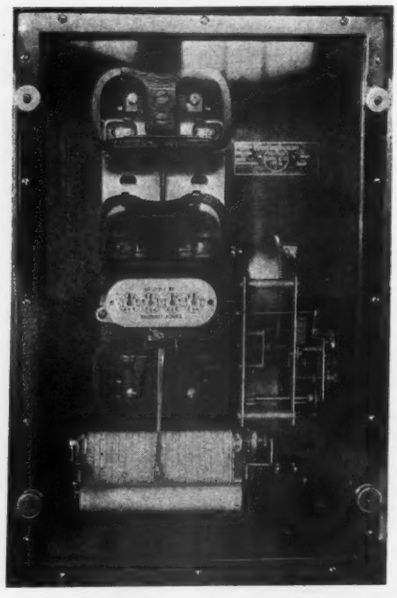


Nicholson all-metal coupling.

Three-Phase Four-Wire Watt-Hour Meter

AS A result of increasing demands and changing conditions, some electric service companies are changing many of their circuits from three-phase three-wire, or two-phase three-wire to three-phase four-wire.

Up to this time the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., has furnished three-element meters in the standard OA house and switchboard types. Now a line of three-element RA demand meters has been added to the OA design, making a complete line of three-element meters to meet the requirements of the central station.



Westinghouse new three-phase four-wire watt-hour meter.

The new meters are similar to the standard RA and OA house and switchboard type meters, differing from them only in that they possess an additional metering element and disk. All of the desirable qualities of the two-element meters are said to be retained in the new product.

Force Feed Lubricating System

ANNOUNCEMENT is made by the manufacturer, Farmer Lubrication Systems, Inc., 2611 Sixteenth Street, Detroit, Mich., of the adaptation of the Farmer Lubricator, which was designed for "one shot" automobile lubrication, to industrial applications. This lubricator consists of a reservoir, the large units of which, it is stated, will hold enough heavy oil, 600-W, to lubricate 30 to 40 bearings for three months. A ball check valve is located at the bottom of the reservoir to prevent the return of the oil to the reservoir as pressure is applied. Oil passes from the reservoir through this check valve into the compression chamber and is forced to the various bearings by this compressor through pipes leading from the compression chamber to them.

Pressure can be applied by hand or foot pressure plungers on the small units or by a screw and handwheel on the piston in the compression chamber of the larger units. The pressure is indicated by a gage and it is stated that a pressure of 1,000 lb. per sq.in. may be applied. The valve of each bearing is designed to supply a fixed amount of oil to the bearing at each "shot," it is stated, and will shut off automatically when the bearing is supplied, irrespective of the amount of pressure in the compression chamber; that is, the valve at the bearing is opened as the pressure is built up and closes as the valve empties. These valves at the bearings can be regulated to supply different quantities of oil.

Air Filter

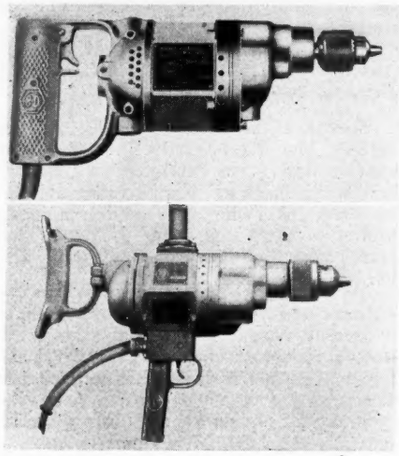
A NEW air filter which the manufacturer states has a number of outstanding advantages has been developed by the American Blower Company, Detroit. By means of this new filter, which is of dry plate design with hair-like tentacles for the arresting and retention of dust and dirt, dust-laden air is divided into a series of small jets which strike the flat filament-coated surface of the plates, dust and soot being projected against the filament, seized and retained. The air, changing its direction and rebounding from this surface, flows through to the next plate and is carried through ten successive dust-removal operations of this type. As dust builds up on these flat surfaces each preceding layer acts as a retentive member, the dust first attracted being itself the principal arresting and retaining factor for the succeeding particles. In this way the use of ad-

hesives is avoided and the maximum load of a cleaner or filter is multiplied.

The outstanding advantages of this type of air filter are said by the manufacturer to be that it is impossible to clog the filter, that it does not require oil or other adhesives which have to be changed from time to time, that it has a constant effect and constant efficiency and that dust builds up on dust and does not get in the line of air flow.

Two New Electric Drills

IMPROVEMENTS on the ¼-in. standard ball bearing electric drill have been announced by The Black & Decker Mfg. Co., Towson, Md. This drill, shown at the top in the accompanying illustration, is intended to replace the light ¼-in. drill made by this company. The new drill is provided with an improved universal motor that drives the



Two new Black & Decker electric drills.

chuck through a double reduction gear unit at a no-load chuck speed of 2,000 r.p.m. All rotating shafts are mounted upon ball bearings. The tool is capable of drilling holes up to ¼ in. in diameter in steel, it is said, and weighs 6 lb.

The lower drill of the two shown is the new ⅝-in. portable electric drill. This drill is designed to drill holes up to ⅝ in. in steel or up to 2 in. in wood. A universal motor, wound with special characteristics for this type of service, is used. Normal open-type ball bearings are used on the armature shaft.

Universal Electric Hoist

UNIVERSAL electric hoists which may be operated interchangeably on direct current or single-phase alternating current of 110 or 220 volts have been placed on the market by Louis E. Emerman & Co., 1761 Elston Ave., Chicago, Ill. This hoist has a minimum headroom of only 11 in., weighs 95 lb. complete, and is built in 500-, 1,000- and 2,000-lb. capacities. The hoist is provided with 12 ft. of load chain and a hook. The hoist unit is shown in the accompanying illustration.

It is stated that the hoist may be operated from any power socket and that a limit stop, which operates with

Universal electric hoist manufactured by Louis E. Emerman & Co.

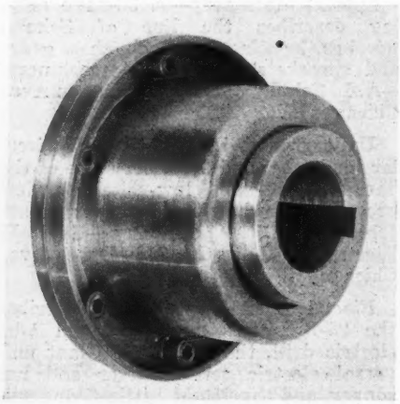
the hook at either end of the chain, shuts off the current when the hook has reached the upper limit of travel. It is also stated that this hoist does not need any holding or lowering brakes and, consequently, hooks may be placed on either or both ends of the chain. According to the manufacturer the full-load lifting speeds for the hoists of the different ratings are as follows: 500-lb. hoist, 28 f.p.m.; 1,000-lb., 12 f.p.m.; 2,000-lb., 6 f.p.m. These units are built for hook suspension or I-beam trolley.

Flexible Couplings

THE new Falk flexible coupling, which is now being marketed by the Falk Corporation, Milwaukee, Wis., has been designed to insure equipment that is directly connected through it against the hazards of all ordinary misalignment.

This coupling consists of two flanged steel disks provided with slots into which is fitted a tempered steel spring formed into a series of hairpin loops, which connects the disks and is the medium through which power is transmitted from one unit to the other. The disks are enclosed in a shell which protects the coupling parts from dirt, acts as a simple fastener for the spring, and as a container for lubricant.

It is said that these couplings are



New design of Falk flexible coupling.

precision-made to fine limits, and that their construction provides for disconnecting the coupled shafts, without disturbing either machine. Also, alignment is reduced to the simplest operation, requiring only a short straightedge and an ordinary set of feelers. These couplings are made in sizes from ¾-hp. to 20,000-hp. capacity at 100 r.p.m.

Insulation Resistance Meter

THE megohm insulation meter shown in the illustration has recently been placed on the market by The Martindale Electric Co., Cleveland, Ohio. This meter weighs only 11 lb. and the readings obtained in testing equipment are said to be independent of the speed at which the generator in the meter is driven. The scale of the instrument, which is graduated to read

Martindale megohm insulation resistance meter.

directly in ohms or megohms, has a range from 200 ohms to 100 megohms. It is claimed that readings can be obtained instantaneously.

Heavy-Duty Meter Element

A NEW, heavy-duty meter element for use in direct-current ammeters, direct-current voltmeters and speed recorders where heavy damping is required has recently been placed on the market by The Esterline-Angus Co., Indianapolis, Ind.

The mechanical construction of this element is similar to that in the standard meter elements, but the magnetic circuit is made stronger, so that the magnetic field in which the coil moves is very intense. This increases both the torque and the damping effect. Increase in torque makes it possible to furnish direct-current ammeters which will give full scale deflection on 75 millivolts, and they can be furnished for operation on shunts of either 75 or 100 millivolt drop. The damping effect is said to be such that current sufficient to bring the instrument to full scale can be applied instantaneously, without causing the instrument to overshoot.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Voltage-Regulator — Catalogue S.P.-1734 describes and illustrates the application of various types of regulators for the control of generator voltage.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Non-Breakable Socket — A circular describes the K-28 series composition socket of the bayonet type which, it is stated, is molded of a composition not easily broken.—Line Material Co., South Milwaukee, Wis.

Motors and Fans—"The Emerson Monthly" discusses various applications of Emerson motors and fans for industrial and other purposes.—The Emerson Electric Mfg. Co., 2012-32 Washington Ave., St. Louis, Mo.

Safety Switches—Catalog No. 32 describes and illustrates various types of safety switches, and the tables which accompany the illustrations give prices, sizes and other data.—Square D Co., Detroit, Mich.

Lamp Reflectors—The Durex type of reflector and canopy can be had in several different styles which are described and illustrated in a new pamphlet.—Wheeler Reflector Co., 275 Congress St., Boston, Mass.

Portable Elevators—Bulletin No. 90A describes and illustrates a hand-power type of portable elevator that embodies a revolving base feature.—Revolvator Co., 336-352 Garfield Ave., Jersey City, N. J.

Electric Hand Saw—The Wodack hand saw is described and some of the various uses to which it can be applied are illustrated in a four-page circular.—Wodack Electric Tool Corp., 23-27 S. Jefferson St., Chicago, Ill.

Head and Eye Protective Devices.—Many different types of devices which are designed to protect the eyes and head while welding, grinding, chipping, and similar operations are being performed, are described and illustrated in Catalog No. 26.—American Optical Co., 70 W. 40th St., New York, N. Y.

Loose Pulley Oiler—A circular describes the Gast Oiling Machine for loose pulleys, which is designed to be attached to any loose pulley. This device consists of an oil chamber, a chain oiler, and a bushing which fits into the pulley.—Standard Pressed Steel Co., Jenkintown, Pa.

Transformer Oil Purifier—The No. 600 transformer oil purifier, portable type, is illustrated and described in a leaflet.—The De Laval Separator Co., 165 Broadway, New York, N. Y.

Centrifugal Clutches—Various applications of the Broadbent centrifugal clutch are illustrated in a leaflet. A new 40-page catalog contains very complete information relating to the application of these clutches to electric drives.—T. V. Cotter & Sons, 859 Broadway, S. Boston, Mass.

Tractors—Bulletin No. 106 describes and illustrates the Mercury Type H electric tractor. Bulletin A-25 discusses the Type A-510 heavy-duty trailer.—Mercury Manufacturing Co., 4118 S. Halsted St., Chicago, Ill.

Hydraulic Presses—A new quarterly publication "The Hydraulic Press" describes and illustrates various types of hydraulic presses and discusses applications.—The Hydraulic Press Mfg. Co., 20 E. Broad, Columbus, Ohio.

Overhead Carriers—A pamphlet, illustrating and describing some of the advantages of the Cleveland Tramrail Systems as applied to moving material about a factory, is now available.—The Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Transformers — Bulletin 232 illustrates the various types of Moloney transformers and shows applications.—Moloney Electric Co., St. Louis, Mo.

Aluminum Conduit Fittings.—Catalog 5 covers the Veco line of vapor-proof junction boxes and other fittings manufactured from a special aluminum alloy.—The Veco Mfg. Co., South Norwalk, Conn.

Rolling Doors—A 32-page catalog illustrates by photographs and sketches various types of steel rolling shutters and doors and Underwriters' labeled rolling fire doors and shutters.—Cornell Iron Works, 36-20 Thirteenth St., Long Island City, N. Y.

Special Machinery—A 38-page catalog describes the line of Schultz winches, hoisting crabs, clutches, gears and sprockets, and special machinery.—A. L. Schultz & Son, 1675 Elston Ave., Chicago, Ill.

Underground Distribution—A circular illustrates and describes some of the various high- and low-voltage underground cable distribution boxes manufactured by this company.—G & W Electric Specialty Co., 7780 Dante Ave., Chicago, Ill.

Electric Drill—A circular describes the 25-B Little Giant universal ¼-in. electric drill, the 252 Little Giant universal electric screw driver and nut runner, and the 250-M Little Giant universal electric tapper.—Chicago Pneumatic Tool Co., 6 E. Forty-fourth St., New York, N. Y.

Flexible Shafts—Booklet B shows the various types of Strand flexible shafts and their application to equipment for grinding, drilling and other similar services.—N. A. Strand & Co., 5001-5009 N. Lincoln St., Chicago, Ill.

Spray Cooling Systems—A book entitled "Spray Cooling Systems" gives interesting data on the operation of cooling systems for cooling, condensing and circulating water.—Binks Spray Equipment Co., 3114 Carroll Ave., Chicago, Ill.

Distribution Transformers—Westinghouse Type SK steel-clad distribution transformers are described in detail together with the outstanding features of their application and construction, in leaflet 20,133-A.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Force-Feed Lubricators—A general catalog describes the various types of centrally-controlled, force-feed oiling systems for industrial and power-plant machinery.—Hills-McCanna Co., 2025 Elston Ave., Chicago, Ill.

Entrance Switches—Catalog 20 describes the Wadsworth line of meter service and main entrance switches in which the main or service fuses are accessible only when the switch is open and the fuses are dead.—The Wadsworth Electric Mfg. Co., Covington, Ky.

Arc Welder—A circular describes the Hansen arc-welding generator which, it is stated, needs no external stabilizing device to assist the operator to strike and maintain the arc. This condition is obtained by a novel position of the commutating pole winding.—Northwestern Mfg. Co., Milwaukee, Wis.

Hoists and Cranes—Catalog 11 is a 72-page handbook on chain hoists, trollays, hand cranes and allied equipment. It contains illustrations and general descriptive matter, as well as line drawings giving all dimensions and the required clearances of the various types.—Wright Mfg. Co., Lisbon, Ohio.

Pneumatic Tools—A 60-page catalog describes the O line of Super-Pneumatic tools, such as high- and low-speed drills, reversible slow-speed drills, grinders, and a saw attachment.—William H. Keller, Inc., Grand Haven, Mich.

Ball-Bearing Motors — A 32-page booklet entitled, "Better Motors with Fafnir Ball Bearings," discusses the operating economies, such as reduced maintenance and repair cost, together with other advantages, which it is stated, result from the use of ball bearings in motors.—The Fafnir Bearing Co., New Britain, Conn.

Mica and Mica Products—A catalog bearing the above title contains much information about the use of these materials for electrical insulation—William Brand & Co., 27 E. Twenty-second St., New York, N. Y.

Rebuilt Electrical Equipment—Frequent bulletins list the various units of new and rebuilt electrical equipment for sale by this company.—Fuerst-Freidman Co., 1292 E. Fifty-third St., Cleveland, Ohio.